ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Vol. XLVIII. No. 11.

TABLE OF CONTENTS.

(20 pages; no insct.)

ENGINEERING NEWS OF THE WEEK..... 181
The Materials for the Concrete of the Buffalo Breakwater (illustrated) 182
Specifications for Foundry Supplies..... 184
The San Leandro Earth Dam of the Oakland Water-Works (illustrated) 187
Experiments in Evaporation from the Soil at the Wyoming Experiment Station..... 187
Railway Competition with Canals..... 188
Difficult Work on the Mendon Tunnel on the New Railway from Paris to Versailles (illustrated)... 188
Final Report of the New England Water-Works Association Committee on Standard Specifications for Cast-Iron Pipe 193
Explosion of an Economizer (illustrated)..... 194
Book Reviews 194
Some Early Submarine Torpedo Boats (illustrated). 195
The Operation of Centrifugal Mine Pumps at Horcajo, Spain 196
A Proposed New Brooklyn Bridge Trolley Terminal Plan (illustrated) 191
Engineers' Report on the Garbage Furnaces of Trenton, N. J..... 197
Sand Washers for the Slow Sand Filters of Mt. Vernon, N. Y. (illustrated)..... 200
EDITORIAL NOTES 190
The Highest Earth Dams in the World—Prospects in the Iron and Steel Trade—Records of Rainfall Observations—Making Horseshoeing a "Close" Profession—A Better Outlook for the American Water-Works Association—An Engineering Investigation of the Trenton Garbage Disposal Works—The Brooklyn "Eagle" on Passaic Valley Sewage Disposal—Precautions Against Lightning Strokes.
EDITORIAL:
The New York Barge Canal Project Again..... 191
LETTERS TO THE EDITOR.....191, 192
Subdividing Land Below a Meandered Boundary—Effect of Back Water from Dams on Meadow Lands—Methods of Work in Government Land Surveys—The Box Column; Experience with Phoenix Columns—The Hydraulic Air Compressor at Norwich, Conn.—Why Sewage is Not Made a Source of Revenue—Universal Irrigation.

A SINGLE-PHASE ELECTRIC INTERURBAN railway is being constructed between the cities of Washington, Baltimore and Annapolis, in Maryland. The Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., has contracted for the equipment of the road, and will install a system of single-phase alternating-current traction which it has experimentally developed. The line in question runs 31 miles from Washington to Baltimore, and has a branch 15 miles long to Annapolis. It will also include an existing line from Washington to Laurel, Md., 14 miles long, which is at present operated by direct current. Current for the system will be generated at Hyattsville, near Washington, and distributed at 15,000 volts; transformers will lower this pressure to 1,000 volts for supply to the trolley wire. It is contemplated to operate this system on a high-speed schedule, with maximum speeds of about 60 miles per hour. The cars are to be about 60 ft. long and very heavy, weighing 50 tons each; each car will be equipped with four 100-HP. motors. These motors are the essential novelty of the system, but no information concerning them is as yet available. The new electric line will be described in a paper to be presented before the American Institute of Electrical Engineers on Sept. 26 by Mr. B. G. Lamme, who has had charge of the experimental working out of the system.

A UNIQUE ELECTRIC DISTRIBUTION SYSTEM has recently been installed in Switzerland. It exactly reverses the usual method of distributing electricity, where alternating current at high potential is used on the transmission line and by means of transformers and rotary converters this is changed to low-tension direct current for utilization. The system in question comprises a line 35 miles long, between Lausanne and St. Maurice. A water-power generating station of 5,000-HP. capacity at St. Maurice generates direct current at a pressure of 23,000 volts; this is transmitted to Lausanne and here, by means of motor-generator sets, generates polyphase alternating current for local distribution. The high-pressure current is produced by ten dynamos connected in series, so as to give a pressure drop of about 2,300 volts across each; a constant current of 150 amperes is generated, and variations in demand are accommodated by varying the potential of transmission. At the receiving end the motors of the motor-generators are connected similarly. The system was installed by the Compagnie de L'Industrie Electrique de Géneve. The plan which they submitted was selected from plans and bids submitted by the leading electrical firms of Switzerland because of its lower first cost.

BIDS FOR ELECTRICAL EQUIPMENT of a portion of the lines of the Northeastern Ry. Co., in England, have been called for. The section of line in question is a loop running from Newcastle-on-Tyne through Tynemouth to Ponteland, part four track and part single track, but mostly double track, in all about 80 miles equivalent of single track. The larger part of this line is to be operated with three or four-car trains, having two motor coaches; the traffic is to be heavy suburban traffic. A section fifteen to twenty miles long is for freight traffic only, and this will be worked by electric locomotives. The specifications issued by the railway company with its call for bids are very broad, and leave the system to be used open to the bidder, but a preference is expressed for a third-rail direct-current system at about 650 volts pressure. The 90-lb. track rail (one) may be used for return. The supply of current, which is three-phase, 40-cycle, 6,000-volt, is given, but the matter of substations is left to the bidder. The tenders are to cover the erection and equipment of the substations, the provision of all high and low-tension cables, and the electrical equipment of 50 motor coaches, 30 trailer coaches and 2 electric locomotives for freight traffic. Bids are to be in by Oct. 7, 1902.

TRACK ELEVATION IN CHICAGO is now in progress on the line of the Chicago & Alton Ry., from 18th St. to Western Ave. Boulevard. All retaining walls and bridge abutments are of concrete, but for a part of the distance an ordinary embankment is built, without retaining walls. The filling is of sand, hauled in by very long trains of 80,000-lb. gondola cars, some of which have side doors (hinged at the top), while others have no doors. The streets are crossed by plate-girder bridges having floors of creosoted plank, covered with stone ballast.——The Chicago & Northwestern Ry. is now elevating its freight yard at Western Ave., and next season will extend the elevation of its main tracks east to within a few blocks of the river. The raising is done by sand shoveled from trains of gondola cars, the filling being done for a few tracks at a time, with cribbing of old ties to make a vertical wall and prevent the sand from flowing over adjacent tracks. Sewers and drains must be laid under the new grade. Trenches are therefore dug in the sand and the concrete work put in without interfering with traffic on the raised tracks.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pennsylvania R. R., near Frugality, Pa., on Sept. 7. A freight train broke in two, and later the rear section ran into the forward part, wrecking several cars. Two men of the train crew were killed.

A FATAL TROLLEY CAR COLLISION is reported from St. Paul, Minn. The collision occurred on Sept. 7 on the line from St. Paul to Fort Snelling; a number of persons are said to have been killed.

THE BOTTOM OF A LARGE GAS TANK shifted and fell while being lowered to its concrete foundation in the Williamsburg section of Greater New York, on Sept. 3. The tank was under construction for the Brooklyn Union Gas Co., at Wythe Ave. and N. 12th St., Williamsburg, by Bartlett, Hayward & Co., of Baltimore, Md. The bottom was 192 ft. in diameter, and was composed of steel plates reported to be ⅜-in. thick. At the time of the accident the bottom had been lowered some 6 ins. by means of jack screws to within 26 ins. of the concrete. According to reports, the supports tipped to one side, throwing the bottom some 30 ins. off the foundation. A number of men were beneath the bottom, five of whom were crushed to death.

THE SAFETY OF LIFE AT SEA is discussed in a recent Parliamentary return dealing with the number of lives lost from British ships by wreck, drowning or other accidents. The "Syren and Shipping," of London, summarizes the statistics given as follows:

Taking the year 1901 and contrasting it with 1891 and 1881, we have the following instructive facts:

	Officers and men employed.	Lives lost.
1881.		
In sail	93,246	2,262
In steam	93,473	1,016
1891.		
In sail	63,357	1,066
In steam	154,890	826
1901.		
In sail	38,400	566
In steam	187,043	686

Summarizing these figures for the purpose of readier comparison we have:

	Men employed.	Lives lost.
1881	186,719	3,278
1891	218,247	1,892
1901	225,443	1,252

The passengers lost during each of these years from British ships were as follows:

1881	231
1891	578
1901	12

A NEW SPEED RECORD FOR STEAMSHIPS was established on Sept. 6 by the steam yacht "Arrow," built after designs by Mr. C. D. Mosher, of New York, and owned by Mr. Chas. R. Flint, of the same place. The vessel covered a measured nautical mile in the Hudson River, off Irvington, N. Y., in 1 min. 32 sec.; this is at the rate of 39.2 knots, or 44.1 statute miles per hour. The tide was in at the time of the trial, and there is said to have been no perceptible current. The "Arrow" is of the following dimensions: Length on water line, 130 ft.; beam, 12 ft. 6 ins.; depth, 9 ft. 4 ins.; normal draft, 3 ft. 10 ins.; draft under screws, 4 ft. 11 ins.; normal displacement, 78 tons. The vessel has two quadruple-expansion engines, with cylinders, 11, 17, 24 and 32 ins. by 15 ins. stroke. With steam at 375 lbs. and at 600 r. p. m., the engines indicate about 4,000 HP. The two boilers, water-tube, have about 5,540 sq. ft. of heating surface. The hull was built by S. Ayers & Sons, of Nyack, N. Y., the engines by the L. Wright Machine Works, of Newark, N. J., and the boilers by Lewis Nixon, of Elizabeth, N. J.

AN ELECTROLYSIS SUIT AT MILWAUKEE, WIS., has been brought by Christopher Dorsch against the Milwaukee Railway & Light Co. From the information in hand it would appear that the city held the plaintiff responsible for the leak in a lead service pipe passing beneath a trolley line, and that as a result the plaintiff has brought the suit against the company. Damages to the amount of $201 are asked.

AN ENGLISH ELECTRIC AUTOMOBILE competition, promoted by the Automobile Club, of London, has had to be postponed for the second time, due to the small number of entries. The proposed competition was to include tests of hill-climbing speed, electrical and commercial efficiency, etc., and a number of test runs to points near London. However, even though the competition had already been once postponed, only two entries were received, and these by the same company, so that a second postponement became necessary. This virtual failure may, of course, be due in part to any of a number of causes, but our London contemporary, the "Electrician," from which we gather the above information, makes it the basis for serious complaint against the manufacturers of electric automobiles, charging them with either lack of enterprise, or else inability to build a vehicle that could make satisfactory showing in the proposed tests.

A PORTABLE PNEUMATIC CAISSON or diving bell in use on a California gold dredger is described as follows by the "Mining & Scientific Press" of San Francisco:

The dredger on which it is used consists of three pontoons, instead of two, so that two wells are provided. One well accommodates the bucket ladder, the other the pneumatic scraper. The apparatus consists of an iron tunnel, swinging upon an axle, which allows the lower end of the tunnel to be raised or lowered at will down to a depth of 65 ft. The tube is let down flush onto the bottom after the buckets have done their work, and the water is then expelled by pneumatic pressure. Men can then enter the tunnel and work at the bottom, scraping out the cavities in the rock which cannot be reached by the buckets.

A FLOATING DRY-DOCK for the Port of Durban, South Africa, has recently been launched at the yards of Swan & Hunter, Wallsend-on-Tyne, England, and will soon be started toward its destination in tow of one of Bucknall Bros. cape-trading steamers. The dock was designed by Clark & Stanfield, of 11 Victoria St., Westminster, and is capable of lifting a ship of 4,500 tons. Its extreme length over platforms is 375 ft., and its width is 87 ft. The distance between guard timbers on the side walls is 61 ft. While still retaining a freeboard of 4 ft., the dock can take a vessel drawing 18 ft. of water over keel blocks 4 ft. high. Structurally, the dock consists of two side walls and a bottom formed of three pontoons. The pontoons are connected to the two side walls by means of movable joints, so that any of the pontoons can be removed and lifted by the dock itself, thus making it self-docking in all its parts. The machinery for operating the dock is contained in the upper parts of the two side walls, and consists of duplicate installations, each comprising a boiler and two pumps. An electric lighting installation is provided for night work.

THE SUBMARINE AND LAND TELEGRAPHS of the world are described in a recent monograph, published by the U. S. Bureau of Statistics. There are 1,750 submarine telegraphs aggregating in length nearly 200,000 miles, laid at a total estimated cost of $275,000,000. Over 6,000,000 messages are annually transmitted over these lines. Adding to the submarine lines the land telegraph systems of the world we have a total length of line of 1,180,000 miles, or 3,800,000 miles of single wires. The total number of messages sent every year over these lines amounts to about 400,000,000, or more than one million per day. In discussing the proposed Pacific cable, and its great length of line, the statement is made that the length of the French cable, between Brest and Cape Cod, is 3,250 miles; while the Pacific lengths are—San Francisco to Hawaii, 2,089 miles; Hawaii to Wake Island, 2,040 miles; Wake Island to Guam, 1,200 miles; Guam to Manila, 1,520 miles, and Manila to Asiatic coast, 630 miles. As to the depth at which the Pacific cable is to be laid—18,000 to 20,000 ft., the cable recently laid between Haiti and the Windward Islands is 18,000 ft. deep. The greatest depth found on the Pacific line is between Midway Island and Guam, or 31,614 ft.; but this depression may be avoided by a detour, giving 20,000, or possibly 18,000 ft.

THE MATERIALS FOR THE CONCRETE OF THE BUFFALO BREAKWATER.

By Emile Low,* M. Am. Soc. C. E.

In the May 29, 1902, number of Engineering News there appeared an extremely interesting and valuable article by Major T. W. Symons, Corps of Engineers, U. S. A., describing in minute detail the new shell concrete superstructure of the South Harbor section of the Buffalo Breakwater. Owing to the magnitude of this work and the departure from ordinary methods as usually practiced in concrete construction, this work has excited more or less attention from engineers. One prominent innovation introduced by Major Symons was the use of unscreened broken limestone, or, as it might be termed, the "run of the crusher," this material including everything passing through the crusher.

FIG. 1. VIEW OF QUARRY FOR BROKEN STONE FOR CONCRETE BREAKWATER AT BUFFALO, N. Y.

FIG. 2. VIEW OF CRUSHER PLANT AND METHOD OF LOADING CRUSHED STONE INTO CANAL BOATS.

For the benefit of the many readers of Engineering News, some further details of this work are offered.

The quarry, Fig. 1, from which most of this crushed stone was obtained is located a little over a mile west of the town of Lockport, N. Y., on the south bank of the Erie Canal. The canal at this point passes through a deep rock cutting, the water level being generally about 30 ft. below the surface of the ground. The quarry covers an area about 200 ft. square, and the rock was obtained by working downward over the whole surface, with low faces, instead of by means of high vertical faces, as is usual in a stone quarry.

The building containing the engine and boiler used in driving the crusher was at the old elevation of the ground, and adjacent to it was located the crusher plant. This necessitated the drawing up of the excavated material on narrow-gage cars by cable, the tracks being shifted as the work required. The crusher used was a Gates rock and ore breaker No. 5, which has a rated capacity of from 25 to 40 tons per hour and produces fragments not exceeding 2 ins. or a little larger in size. Leading from the crusher was a wooden spout, which delivered the broken stone directly into a canal boat below, Fig. 2. The average canal boat load was about 110 cu. yds. The canal boats were towed by a tug to the breakwater at Buffalo, a distance of 35 miles. The limestone from which the crushed stone was manufactured weighed 166 lbs. per cu. ft.

The gravel and sand were obtained from the bed of the Niagara River, off the shore of Strawberry Island, a short distance below the International Bridge. For this purpose a so-called "sand sucker," the "R. A. Burton," Fig. 3, owned by the Point Abino Sand Co., was employed. As this is an interesting contrivance, a short description of it is given here. The vessel consists of a wooden hull, 132 ft. long, 30.2 ft. beam and 7.2 ft. depth. At the stern the propelling machinery is installed, consisting of a double non-condensing engine with a steam cylinder 14 ins. in diameter and of 16 ins. stroke. The boiler is of steel, 13 ft. long and 90 ins. in diameter. It has six flues, 4 ft. 7 ins. long, two being 11 ins., two 12½ ins. and two 14 ins. in diameter and 5-16-in. and ⅜-in. thick. The boiler is allowed to carry 130 lbs. steam pressure.

At the bow is located a centrifugal pump made by the Morris Machine Works, of Baldwinsville, N. Y. The suction pipe is 12 ins. in diameter, as is also the discharge pipe. The pump is driven by two direct-connected engines with cylinders 9 ins. in diameter and 9 ins. stroke. The steam is furnished by the boiler which supplies the propeller.

Located on the deck of the scow is a large wooden box, 85 ft. long, 29 ft. 4 ins. wide and 3 ft. 10 ins. deep, divided into two compartments by a wooden bulkhead 4 ins. thick. Each compartment is thus 14 ft. 6 ins. wide and 85 ft. long. The capacity of the box is about 325 cu. yds. The sides of the box are kept from spreading by six wooden spreaders, Fig. 4, spaced equidistant apart. The spreaders are provided at the outer ends with an iron hook, which holds them in place. These spreaders also provide a footing for the wooden horses or trestles which carry a wooden flume, Fig. 5, which extends the length of the scow. The water charged with gravel and sand is pumped from the bottom of the river (generally 12 ft. deep) and flows in the flume. The bottom is supplied with suitable openings, in which changeable screens are fitted, the size of the screens regulating the size of the resulting sand or gravel. These screens are composed of a wooden frame about 24 ins. long and 11 ins. wide The sand screens are made of ¼-in. wire, spaced ¼-in. apart. The wire is supported every 3 ins. by a ½-in. rod, around which it is wound. There are 22 rows of wire. For the gravel screens wire rods ¾-in. in diameter are used and spaced with ½-in. openings between, making eight rows of bars.

About four hours were required to pump a scow load of sand and gravel, after which the sand sucker was propelled by its own power to the storage yards located on the west bank of the Erie Canal at the foot of Pennsylvania Ave., in the city of Buffalo, where it was unloaded by means of a clam-shell revolving McMyler derrick. The same appliance was used to reload the sand onto the material boats which carried it and the cement to the work. See Fig. 6.

During the season of 1901 a number of [illegible] the characteristics of the concrete materials made. The result of the tests is shown in [illegible] I. and II. These tests were made as f[illegible] Wooden boxes made of planed 1-in. pine [illegible] containing exactly 1 cu. ft., were used. [illegible] were filled with the various materials, [illegible] shaken down and the top leveled off. The [illegible] and gravel were then sifted through a sieve [illegible] taining six meshes to the inch, or 36 per [illegible] The resulting screenings were then weighed [illegible] measured separately. In the case of the [illegible] stone the material was first screened through a ¾-in. sieve and then through the smaller, [illegible] 36, the separate screenings being also weighed [illegible] measured.

From the table it will be noted that 1 cu. [illegible] sand contained 0.47 cu. ft. of fine gravel, the g[illegible] of which ranged from ⅛ to ¼-in., and 0.59 cu. ft. of gravel, the respective weights being 47.2 and 59.3 lbs., equivalent to, roughly, 100 lbs. per cu. ft. for the screened or 106.5 lbs. for the combined materials.

The gravel was found to contain for 1 cu. ft. 0.80 cu. ft. of gravel, generally ⅜-in. in size, and 0.29 cu. ft. of sand, the respective weights being 81.5 and 29.2 lbs., again indicating closely 100 lbs. per cu. ft. for the screened, or 110.7 lbs. for the combined materials.

The broken stone showed 0.63 cu. ft. of coarse and 0.33 cu. ft. of fine stone and 0.11 cu. ft. of dust, weighing, respectively, 53.8, 30.4 and 11 lbs. for the screened, or 95.2 lbs. for the combined materials. This latter weight, however, does not show the correct weight of the broken stone as it was used in the work, for the reason that in a box containing only 1 cu. ft. it is extremely difficult to shake down the stone as can be done in a larger receptacle.

In order to ascertain the actual weight of the broken stone per cubic foot as used, three canal boat loads of stone were accurately measured and also the displacement taken. From these determinations it was found that a cubic foot of unscreened broken limestone weighed 101 lbs. As a further check the voids of two steel buckets filled with this material and each containing 21.6 cu. ft. were obtained and found to be 39%. From the known weight of the stone, 166 lbs. per cu. ft., the

TABLE I.—Showing Relative Proportions of Different Aggregates Used in Making Concrete.

(For screening the sand-grit and gravel, a No. 36 sieve was used, opening ⅙-in., and for the unscreened broken stone first a ¾-in. sieve, and then the No. 36.)

Date.	Sand grit.			Gravel.			Unscreened broken stone.			
							Stone.			
	Fine gravel, cu. ft.	Sand, cu. ft.	Total, cu. ft.	Fine gravel, cu. ft.	Sand, cu. ft.	Total, cu. ft.	Coarse, cu. ft.	Fine, cu. ft.	Sand, cu. ft.	Total, cu. ft.
Aug. 16	0.61	0.39	1.00	0.70	0.37	1.07	0.58	0.31	0.10	0.99
" 24	0.45	0.60	1.05	0.91	0.12	1.03	0.52	0.42	0.16	1.10
" 29	0.41	0.69	1.10	0.99	0.10	1.09	0.74	0.28	0.12	1.14
Sept. 7	0.40	0.70	1.10	0.67	0.41	1.08	0.55	0.42	0.07	1.04
" 14	0.29	0.74	1.03	0.81	0.28	1.09	0.67	0.33	0.05	1.05
" 21	0.54	0.46	1.00	0.59	0.51	1.10	0.57	0.36	0.14	1.07
Oct. 4	0.41	0.70	1.11	0.85	0.24	1.09	0.57	0.38	0.10	1.05
" 12	0.46	0.61	1.07	0.74	0.37	1.11	0.75	0.25	0.10	1.10
" 25	0.57	0.51	1.08	0.93	0.17	1.10	0.66	0.28	0.10	1.04
Nov. 2	0.53	0.56	1.09	0.78	0.36	1.14	0.64	0.31	0.19	1.14
Total	4.67	5.96	10.63	7.97	2.93	10.90	6.25	3.34	1.13	10.72
Average	0.47	0.59	1.06	0.80	0.29	1.09	0.63	0.33	0.11	1.07

Note.—The original volume in every case was exactly 1 cu. ft.

*U. S. Engineer Office, 540 Federal Building, Buffalo, N. Y.

broken stone would weigh 101 lbs., a very close agreement.

From a large number of tests it was found that one bag of cement contained 0.92 cu. ft. and weighed a little over 100 lbs. per cu. ft.

Major Symons' article gives the required quantities for a cubic yard of concrete blocks. Multiplying these quantities by the weight of the various concrete ingredients as found by the tests, we have the following table:

4.86	cu. ft. of	cement × 100.6 lbs. = ...	488.9 lbs.
4.86	" "	small gravel × 110.7 lbs. = ..	538.0 "
9.72	" "	sand grit × 106.5 lbs. = ...	1,035.2 "
19.44	" "	unscreened broken stone, 101.3	1,969.3 "
		Total	4,031.4 lbs.

or 149.3 lbs. per cu. ft.

By a very ingenious contrivance in the form of a counter attached to the boom of the derrick, which handled the mixed material, an almost absolute count of the number of batches of concrete which were placed in the concrete superstructure was obtained. The concrete superstructure was built in three stages—first the banquet deck, then the parapet walls, and last the parapet deck. A separate account was kept of the batches entering into each part of the work, and these were found to be, respectively, 2,577, 3,808 and 4,695, making a total of 11,080 batches. The following table shows the theoretical quantities in each part of the work, batches of concrete and actual quantity of finished concrete made for each batch:

Place in work.	Cu. yds.	Cu. ft.	Batches.	Concrete made for 1 batch.
Banquet deck	2,786.46	75,234.42	2,577	29.2
Parapet walls.....	4,052.92	109,428.84	3,808	28.8
Parapet deck	4,960.79	133,941.33	4,695	28.5
Total	11,800.17	318,604.59	11,080	28.8

Each batch of concrete was made up of the following ingredients:

Cu. ft.		Parts.
5.4	cement	1
5.4	gravel	1
10.8	sand grit	2
21.6	unscreened broken stone	4
43.2	Total	7

There is a slight discrepancy of the concrete made per batch in the different parts of the work for the reason that the actual separate quantities varied somewhat slightly from the theoretical ones, the total, however, being absolutely correct.

Especial care was taken to measure the different concrete ingredients very carefully and accurately. For the mass concrete the gravel was measured in small wheelbarrows, the boxes of which were of the following dimensions: Bottom, 1.54 ft. square; top, 1.88 ft. square; depth, 0.92 ft.; contents, 2.7 cu. ft. Two barrow loads were used in each batch. For the sand large wheelbarrows were used, having a bottom 1.81 ft. square, a top 2.15 ft. square, a depth of 0.92 ft., and containing 3.6 cu. ft. Three barrow loads were used in each batch. For the broken stone a steel bucket, with a bottom 2.5 × 3.0 ft., a top 3.0 × 3.5 ft. and a depth of 2.4 ft., was used, the cubical contents being 21.6 ft. To each batch was added six bags of cement. From tests made it was found that the voids in the sand, grit and gravel did not vary much from 27%. The voids of the unscreened broken stone have already been stated to be 39%. From these data the following table is determined:

Quantities.	Material in One Batch.	Percentages of solid contents.	Resulting solid contents, cu. ft.
Cement	5.4 cu. ft.	0.90	4.86
Gravel	5.4 "	0.73	3.94
Sand grit	10.8 "	0.73	7.88
Unscr'ned brkn stne	21.6 "	0.61	13.18
Total	43.2 cu. ft.	....	29.86

Regarding the quantity of sand, the specifications required two parts for each part of cement. This requirement was closely approximated, as will be observed from the table below. In this connection it must be borne in mind that the sieve used for sand was rather small, viz.: No. 36, or six meshes to the inch.

1	part gravel	containing	0.29	part sand	= 0.29
2	parts sand grit	"	.59	" "	= 1.18
4	parts unscreened stone*	"	.11	" "	= .44
	Total parts				1.91

*Broken stone.

During the season of 1902 some tests of the concrete materials were made, substituting a ¼-in. sieve for the 1-6-in. one, and also passing the residue through a 1-10-in. sieve. Tables III. and IV. show the results.

TABLE III.—Showing Physical Composition of 1 Cu. Ft. of Unscreened Broken Limestone Tested in 1902.

No. of test.	Left on ¾-in. sieve, coarse.	Left on ¼-in. sieve, fine.	Passed ¼-in. sieve, sand	Total	Left on 1/10-in. sieve, Sand left on.	Passed 1/10-in. sieve, Sand passed.	Voids, %
1	0.50	0.40	0.22	1.12	0.13	0.10	39
2	0.55	0.35	0.19	1.09	0.10	0.09	39
3	0.52	0.40	0.20	1.12	0.10	0.10	41
4	0.65	0.35	0.15	1.15	0.09	0.06	42
5	0.53	0.39	0.22	1.14	0.12	0.10	39
Total ..	2.75	1.89	0.98	5.62	0.54	0.45	200
Average ..	0.55	0.38	0.20	1.13	0.11	0.09	40

TABLE IV.—Showing Physical Composition of 1 Cu. Ft. of Gravel from Niagara River Tested in 1902.

No. of test.	Fine gravel.	Sand.	Total.	Weight, lbs.	Voids, %.	Weight solid, cu. ft.
1	0.48	0.58	1.06	113	25	151
2	0.50	0.56	1.06	110	27	151
3	0.54	0.50	1.04	113	28	157
Total	1.52	1.64	3.16	336	80	459
Average	0.51	0.55	1.06	112	27	153

The above data refer more particularly to the mass concrete. Some further information relative to the large concrete blocks, given in Table V., may be interesting:

The superstructure was not quite finished at the end of the season of 1901, due to the very stormy weather, but was completed early in the season of 1902, between April 17 and May 10, during which time 2,610.66 cu. yds. of mass concrete were placed. During this period 2 banquette decks, 10 parapet walls and 17 parapet decks were placed.

Usually five hours were occupied in placing a parapet deck, containing 100 cu. yds. of concrete. The hours of labor required to lay 1 cu. yd. of concrete were as follows:

1	foreman	0.05 hrs.	37	laborers	1.85 hrs.
2	engine runners	0.10 "			
4	tagmen	0.20 "	45	Total.	
1	fireman	0.05 "			

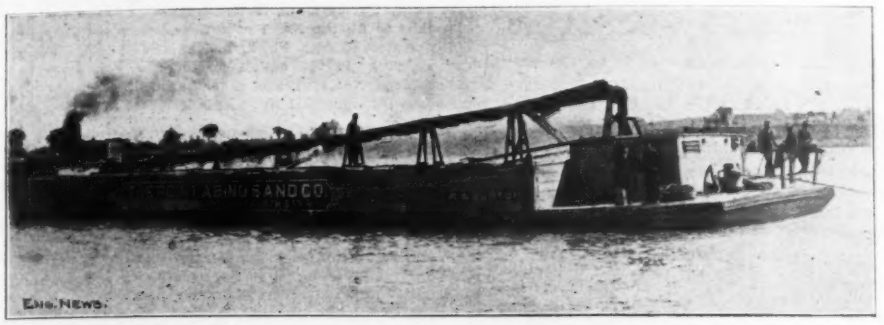


FIG. 3. GENERAL VIEW OF VESSEL FOR EXCAVATING SAND AND GRAVEL FROM RIVER BOTTOM.

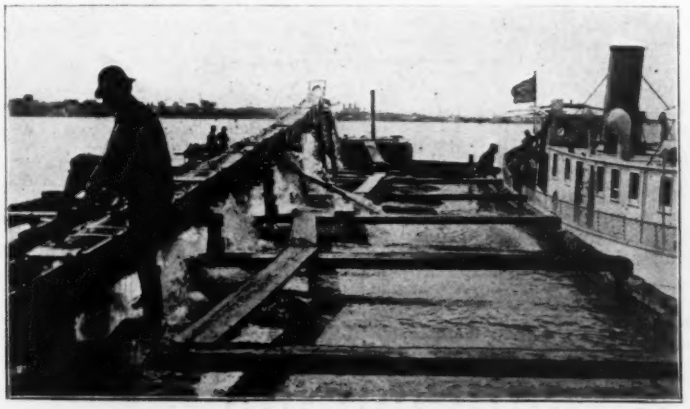


FIG. 4. VIEW OF SAND DREDGE SHOWING STORAGE BIN AND FLUME.

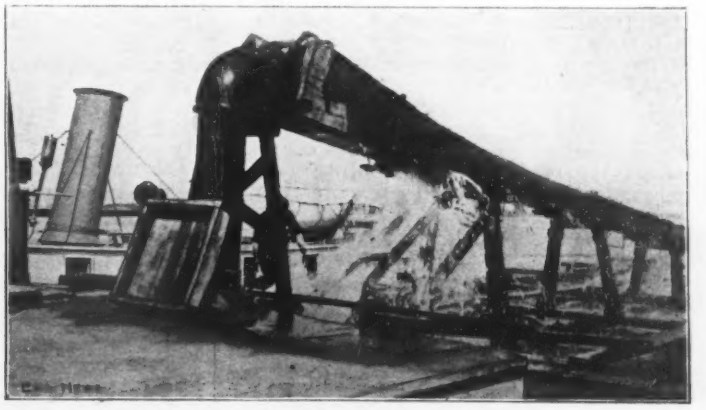


FIG. 5. VIEW OF SAND DREDGE SHOWING FLUME.

The tagmen were employed in swinging the booms of the two derricks handling, respectively, the concrete materials and the mixed concrete.

The great desideratum in making good concrete

TABLE II.—Showing Relative Weights of Different Aggregates Used in Making Concrete.

(After the various materials were screened, they were placed in a cubical wooden box, 1 ft. cube, carefully measured and then weighed.)

Date.	Sand grit—Fine gravel, lbs.	Sand grit—Sand, lbs.	Sand grit—Total, lbs.	Gravel.—Fine gravel, lbs.	Gravel.—Sand, lbs.	Gravel.—Total, lbs.	Broken stone.—Stone—Coarse, lbs.	Broken stone.—Stone—Fine, lbs.	Broken stone.—Sand, lbs.	Broken stone.—Total, lbs.
Aug. 16	64.39	41.26	105.65	75.64	37.14	112.78	51.51	29.51	12.88	93.90
" 24.....	45.76	57.39	103.15	84.27	13.13	97.40	47.26	37.26	16.63	101.15
" 29	40.10	64.65	104.75	95.50	10.00	105.50	59.69	25.25	10.62	95.56
Sept. 7	40.88	67.57	108.45	73.07	41.88	114.95	48.13	38.38	8.29	94.80
" 14.....	29.13	73.32	102.45	84.01	28.13	112.14	59.57	29.63	4.94	94.14
" 27.....	56.57	54.38	110.95	62.17	48.98	111.15	48.13	32.38	14.13	94.64
Oct. 4.....	38.07	69.07	107.14	87.57	24.44	112.01	50.07	36.63	7.94	94.64
" 12.....	45.38	61.82	107.20	78.57	38.00	116.57	61.88	23.44	9.44	94.76
" 25.....	57.01	48.63	105.64	92.64	14.88	107.52	58.45	25.50	9.00	92.95
Nov. 2.....	54.76	55.38	110.14	81.07	35.88	116.95	53.13	26.19	16.04	95.36
Total	472.05	593.47	1,065.52	814.51	292.46	1,106.97	537.82	304.17	109.91	951.90
Average	47.2	59.3	106.5	81.5	29.2	110.7	53.8	30.4	11.0	95.2

Note.—The original volume in every case was exactly 1 cu. ft.

TABLE V.—Showing Number of Concrete Blocks Manufactured Each Working Month; Also the Hour's Time of Various Kinds of Labor Required to Make 1 Cu. Yd. of Concrete.

1901. Month.	Concrete blocks. Days work'd.	Face Lake.	Face Harbor.	Wall Interior.	Wall Parapet cross.	Total.	Cu. yds.	Total hours worked.	Cubic yards per hour.	Hour's labor required to make 1 cu. yd. concrete: Foremen.	Engine runners	Firemen.	Tagmen.	Labor, hrs.
June	8	30	17	17	11	75	611.13	55¾	10.96	0.18	0.09	0.09	0.18	2.46
July	19	90	47	39	33	209	1,709.83	144¾	11.81	0.17	0.09	0.09	0.17	2.26
August	12	58	46	38	24	166	1,338.04	101¼	13.15	0.15	0.15	0.08	0.15	2.48
September	14	60	44	32	22	158	1,283.16	86¾	14.79	0.14	0.14	0.07	0.14	2.42
October	5	12	18	2	10	42	326.42	25¼	12.93	0.15	0.15	0.08	0.15	2.65
Total	58	250	172	128	100	650	5,268.58	414¼	.....	....	....	....	....	....
Average	..	..	..	..	..	..	.....	...	12.72	0.16	0.12	0.08	0.16	2.46

is to use the proper amount of water. This varies with the condition of the sand, gravel and broken stone, whether wet, damp or dry. The smaller mixer, which mixed the concrete for the blocks, was supplied with a circular tank which was 1.9 ft. in diameter and 1.65 ft. high. In this tank was secured a standpipe having holes, respectively, about 0.7, 0.8 and 0.9 ft. from the bottom and which corresponded to volumes of 2, 2.25 and 2.5 cu. ft., nearly. The tank on the larger mixer was 3 ft. in diameter and supplied with a similar standpipe, the lower hole being about 5 ins. above the bottom, the holes being spaced 2 ins. apart. Small screw nuts were inserted in these holes. The trouble with this contrivance was the difficulty of quickly changing these screw nuts. To obviate this, small cubes of concrete 0.5 ft. on the edge were made. These contained 0.125 cu. ft. The holes in the standpipe were fixed for the maximum quantity of water, and when it was desired to change this the small blocks of concrete were added until the required quantity of water was obtained. This arrangement worked very quickly and satisfactory. In this connection it might be well to add that a water tank with an adjustable regulator, working quickly, would be a good thing. The amount of water used for the smaller batches was about 2¼ cu. ft. and for the larger about 3½ cu. ft.

Referring to the matter of weight of this concrete superstructure, the following may be of interest. On the assumption that the concrete will weigh 2 tons to the cubic yard, this weight would be for a

30-ft. section	687.80 tons.
Rubble stone filling, 1 cu. yd. = 1 ton	154.44 "
Total weight	842.24 tons.

or somewhat over 23 tons per lin. ft.

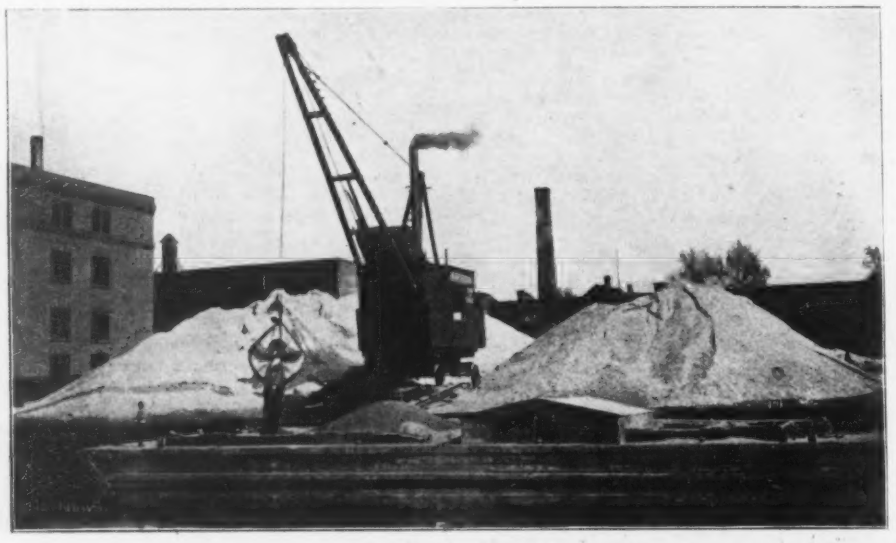


FIG. 6. VIEW SHOWING METHOD OF LOADING SAND AND GRAVEL ONTO MATERIAL BOAT.

SPECIFICATIONS FOR FOUNDRY SUPPLIES.

In all machinery manufacturing establishments the foundry is one of the most important departments, and great skill and care in its management are necessary to ensure the economical production of good castings of quality suitable for the particular purposes for which they are intended. In our issue of July 10 we described at some length the laboratory department of the J. I. Case Threshing Machine Co., at Racine Wis., and also the practice of this department in regard to the regulation of the work of the foundry. In the same article reference was made to the comprehensive series of specifications drawn up by Mr. W. G. Scott, who is at the head of the laboratory department. We have recently received from Mr. Scott a set of the specifications applying to foundry materials. These we reprint for the benefit of our readers, as being of very general interest; besides which they indicate the tendency towards the operation of foundries upon a more scientific basis than has been customary in the past.

The first three of these specifications (1, Foundry pig iron; 2, Coke, and, 3, Scrap) are what are termed "purchase specifications," forming contracts under which the materials furnished must be exactly as specified. They differ in this respect from the other two specifications in the set (4, Molding sand, and, 5, Foundry castings), which are "reference specifications." These latter do not form contracts, but are intended to indicate the desired character of the materials in question:

No. 269.—Foundry Pig Iron.

(Revised July 14, 1900.)

Under these specifications we desire a good, clean iron, as free as possible from dross, kish, oxide, sand, etc.

The percentage of "sows" must not vary to any great extent from the usual amount found in a strictly graded iron, according to the old fracture method.

All grades of pig iron will be bought strictly by analysis, and must conform to the following specified percentages:

FOUNDRY No. 1.

Silicon, must not be less than	2.50%
Sulphur, must not exceed	.03%
Phosphorus, should not exceed	.60%
Manganese, should not exceed	.50%
Total carbon, not specified.	

The carbons will usually be between 3.00 and 4.50% in this grade.

Any car of No. 1 Foundry Pig which shows on analysis less than 2.40% of silicon or more than 0.035% of sulphur will be rejected. (See note.)

FOUNDRY No. 2.

Sicilon, must not be less than	1.95%
Sulphur, must not exceed	.04%
Phosphorus, should not exceed	.70%
Manganese, should not exceed	.70%
Total carbon, not specified.	

The carbons in No. 2 will generally range from 2.90 to 4.20%.

Any car of No. 2 Foundry Pig which shows on analysis less than 1.85% of silicon or more than 0.045% of sulphur will be rejected. (See note.)

FOUNDRY No. 3.

Silicon, must not be less than	1.35%
Sulphur, must not exceed	.05%
Phosphorus, should not exceed	.80%
Manganese, should not exceed	.90%
Total carbon, not specified.	

The carbons in this grade will usually be between 2.50 and 4.00%.

Any car of No. 3 Foundry which shows on analysis less than 1.25% of silicon or more than 0.055% of sulphur will be rejected.

NOTE.—It is distinctly understood that all grades of pig iron will be bought according to analysis and not fracture.

As we mix by analysis in the foundry, it necessarily follows that the pig iron should be according to specifications. Furthermore, if we accept an iron as No. 2 which fails to fill the No. 1 conditions, we might eventually be overstocked with No. 2, and be unable to get the results aimed at in the cupola mixture; consequently any iron sold as No. 1 or any other specified grade, will be rejected if not strictly within the specifications for that grade.

When a car of pig iron is received it will immediately be sampled by an experienced man (professional sampler) who will select a certain number of pigs from different parts of the car, which according to his judgment will represent the *average* quality of the iron. These pigs will be broken and drillings taken from the face of the fracture will be sent to the laboratory for a chemical analysis. The analysis will decide the acceptance or rejectment of the iron. Rejected cars will be held subject to the shipper's order.

In case of dispute, the furnace or the seller shall have the right to resample the iron in conjunction with the buyer, each to select five pigs. Drillings from the ten pigs, after being well mixed, will be divided into three different samples, one lot to be analyzed by the furnace, one by our laboratory, and one by a disinterested chemist, agreed upon by the parties in dispute. The two analyses nearest alike will be accepted as the proper chemical composition of the iron.

In all chemical work relating to pig or cast iron, it is understood that the standardized drillings furnished by the American Foundrymen's Association are to be used as "standards." The following chemical methods are used in our laboratory, viz.:

Silicon—Drown's method.

Sulphur—Evolution and titration with iodine (volumetric), as a rapid method, and the oxidation method (gravimetric) in all cases of dispute.

Phosphorus—"Emmerton's Method" for rapid work, and the "Molybdate Magnesia" method for very accurate determinations.

Manganese—Deshay's or the colormetric method for rapid work, and the "Acetate Process" for extremely accurate work.

Carbons—Carbons are worked by the colormetric and combustion methods.

In case of dispute, check analyses are made by gravimetric methods.

No. 270.—Silver Gray (S. G.) or Silicon Pig.

Under this specification we expect a pig iron medium high in silicon and not too low in graphitic carbon. This iron is to be used as a softener.

Silicon, must not be less than	3.00%
And should not be more than	5.50%
Sulphur, must not exceed	.04%
Phosphorus, should not exceed	.90%
Manganese, should not be less than	.30%
Total carbon, should not be less than	2.50%

Any car of S. G. iron, showing on analysis less than 3.00% of silicon, or more than 0.055% of sulphur will be rejected.

No. 271.—Ferro-Silicon Pig Iron.

Under this specification we prefer a pig iron with about 8.00% silicon. The general range for silicon in this grade is from 6.00 to 12.00%.

Silicon, must not be less than	7.00%
Or more than	12.50%
Sulphur, must not exceed	.04%
Manganese, not specified.	
Total carbon, not specified.	

As a rule the graphitic carbon will be low, varying from 0.00 to 0.50%. Manganese may occasionally vary from 0.20 to 3.00%, or more.

Cars will be rejected which show less than 6.00% of silicon, or more than 0.045% of sulphur.

No. 272.—Manganese Pig (Manganiferous Iron).

In this specification we desire an iron of from 1.00 to 2.50% manganese. The ordinary No. 1 pig iron, running about 1.50% in manganese, will fill all the conditions required.

Silicon, should not be less than	2.50%
Sulphur, must not exceed	.04%
Phosphorus, should not exceed	.70%
Manganese, must not be less than	.90%
Carbon, not specified.	

As a rule, the higher the manganese, the greater the proportion of combined carbon. Combined carbon may range from 0.30 to 3.00%, while the graphitic carbon may vary from 0.40 to 3.50%.

NOTE.—A few remarks on manganiferous iron may help to define the dividing line between the ordinary foundry pig and the regular manganese iron.

Manganese Pig is an ordinary iron made from ore containing somewhat more manganese than the regular foundry irons; it will run from 0.80 to 3.50% in man-

ganese. It is added to foundry pig, in cupola practice, to raise the combined carbon, thereby increasing the strength. In a measure it neutralizes the effect of sulphur, removes excess of gas and prevents blowholes. It must, however, be used with caution, as a low silicon and carbon, with high manganese, gives hard iron and alters the shrinkage.

Spiegel Iron is used mostly in steel making. It is supposed to contain from 10 to 25% of manganese, but some authorities place the range from 3.50 to 20%.

Ferro-Manganese contains from 25 to 90% of manganese. Most of the ferro-manganese on the market runs about 80% of manganese. With 80% of manganese present, there is not much room for iron. The metal, however, usually contains sulphur, phosphorus, carbon and silicon.

In cupola practice the amount of ferro-manganese used is generally very small, consequently the effect of the other metalloids is not great.

Manganese has a tendency to keep the carbon in the combined form; hence it lowers the graphitic carbon, thereby reducing the deflection. It neutralizes the effect of sulphur by reducing "red-shortness," and indirectly offsets the "cold-shortness" or brittleness caused by high phosphorus.

In foundry practice, the more manganese present in the pig, the more silicon and graphitic carbon required to produce soft castings.

For "chill mixtures," where great toughness is required, a pig with 2% manganese and less than 1% silicon is a desideratum.

No. 273.—Malleable Bessemer Pig.

This specification will cover both the "common" and "straight" malleable Bessemer. When the "straight" Bessemer pig is specified, it is understood that the phosphorus is not to exceed 0.10%. Straight Bessemer with 1.00 to 1.50% of silicon, about 0.60% manganese, under 0.11% phosphorus, and below 0.04% sulphur, will be satisfactory.

In "common" Bessemer the following limit will be specified:

Silicon, may range from (Silicon of .....% preferred.)	0.70 to 2.10%
Sulphur, must not exceed	.045%
Phosphorus, must not exceed	.15%
Manganese, may range from (Manganese of .....% preferred.)	0.30 to 1.20%
Total carbon, should not exceed	3.75%

As a rule the combined carbon will vary from 0.30 to 1.30%, and the graphitic carbon from 3.45 to 1.80%.

(Preferred figures will be marked in red ink, and when specified, we expect to get an iron not varying more than 0.10% either way. When no preferred figure is specified, the silicon and manganese may be anywhere within the above limits.)

The iron will be rejected if the analysis shows more than 0.05% of sulphur, or more than 0.18% of phosphorus.

No. 274.—Charcoal Irons.

Charcoal iron differs from coke iron mainly in regard to the carbon.

The graphitic carbon appears to be in a finer state of division, and when changed into the combined form it produces a closer grain and stronger metal than does a coke iron with the same amount of total carbon. It is especially adapted to "chill work," and by regulating the amount of silicon and carbon, it is possible to get any desired chill.

The sulphur, phosphorus and manganese are quite constant in charcoal iron; the silicon and carbon vary to a decided degree, and these two elements will govern the various grades.

Graded according to fracture, there are usually seven distinct grades, designated by letters and numbers, and in some cases branded as "soft," "foundry," "medium," "high," "low," etc. (high and low referring to carbon).

Charcoal iron ranges in silicon from 0.30 to 3.00%. The total carbon will run from 2.50 to 4.50%, in some cases even higher.

In this specification we shall not specify any grade or number, but will ask for "preferred" per cents. as follows:

Silicon, general total range (Silicon of .....% preferred.)	0.30 to 2.75%
Sulphur, must not exceed	.025%
Phosphorus, must not exceed	.25%
Manganese, should not exceed	.70%
Total carbon, general range (Carbon of about .....% desired.)	2.50 to 4.50%

(Preferred figures to be marked in red ink.)

"Low" carbon will be understood to closely approximate 2.50%, "medium" carbon as 3.50%, and "high" carbon as 4.50%, or above.

NOTE.—Charcoal iron gives a "chill" in accordance with the amount of silicon present, the other constituents remaining constant, or nearly so.

The following table is approximate, but near enough to give some idea of the effect of silicon on the carbon:

0.30%	silicon equivalent to	1½-in. chill.
.40%		1-in. "
.52%		⅝-in. "
.70%		¼-in. "
1.00%		⅛-in. "

Above 1.00% a chill may be induced by increasing the sulphur, or by altering the amount of manganese and carbon.

With manganese at 0.50% and sulphur at 0.095% in a mixture, the castings will take on a decided chill even with medium high silicon.

Sulphur increases, silicon diminishes, manganese toughens or stiffens, and phosphorus remains neutral in regard to chill.

A high carbon will give a hard, shallow chill, while a low carbon gives a soft, but deeper chill.

Chill is governed to a great extent by the cooling of the molten iron, different results being obtained by pouring against a large or small surface chill plate; also in pouring horizontally or vertically against the chill. A reverberatory furnace gives better results than a cupola in chilled work, due to the different effect on silicon.

No. 275.—Phosphorus Pig Iron.

Phosphoric iron is used almost exclusively for small thin castings, where great "fluidity" is desired.

A very fluid iron is essential in thin work as it fills every part of the mold and gives a clear solid casting.

Iron high in phosphorus is very weak and brittle under impact (shock), consequently it cannot be used where great strength is required. With high silicon and a high graphitic carbon, the phosphorus may rise to 1.00% in the casting, but in chilled work with low silicon and much combined carbon, the phosphorus must be kept below 0.30%.

This specification calls for an iron within the following limits, viz.:

Silicon, must not be less than (A higher silicon preferred.)	1.50%
Sulphur, must not exceed.	.055%
Phosphorus, should not be below	1.00%
Manganese, may range from	0.30 to 0.90%
Total carbon, should not be below	3.00%

Any car of iron showing on analysis more than 0.06% of sulphur, or less than 0.90% of phosphorus, will be rejected.

REMARKS.—These specifications will be submitted whenever a purchase of pig iron is to be made, with the distinct understanding that there is to be no deviation from the figures specified.

The amount of each grade required, and the terms of contract are to be filled out in the form printed with the specifications.

Special Contract.

(Pig Iron.)

NOTE.—In our specifications for pig iron the words "*must not*" are to be considered as an arbitrary term and admit of no radical change from the specified figure.

The term "*should not*" is intended as a suggestion in regard to what we desire, but is not strictly an absolute factor.

In the event of the party selling pig iron not being able to meet the requirements of the regular specifications, it is proposed that such "off grade" iron be purchased under *special contract*, such contract plainly stating the minimum or maximum limit of silicon, sulphur, etc.

The party selling the iron is to fill in the blanks below with the minimum or maximum amount of the metalloids, and if satisfactory to the purchasing agent both parties are to sign a special contract.

SPECIAL PIG IRON.

Brand	
Silicon, not less than	.....%
Sulphur, not over	.....%
Phosphorus, not over	.....%
Manganese, between .... and	.....%

No. 258.—Specifications for Foundry Coke.

Under this specification we desire a good, clean, 72-hour coke; as free as possible from coke dust and cinder.

The percentage of wall coke, known as "black heads" must not be greater than that usually found in "Selected" No. 1 Foundry Coke.

The coke should be of the massive form, and reasonably free from small particles, i.e., granulated coke.

"Structure" is an important feature and will be considered when purchasing coke.

The structure of a perfect 72-hour coke should, according to theory, be made up as follows:

Cellular structure	56%
Coke structure	44%

We do not expect to get a coke with an ideal structure, but we do insist on a coke with a proper structure for cupola work.

Our castings are made according to specifications; and, as the iron is mixed by analysis, it is absolutely necessary that the coke be low in sulphur and phosphorus.

Well-washed coke should not exceed the amount of sulphur herein specified.

When a car of coke is received it will immediately be sampled by an experienced man, who will select two average samples (ten pieces) of the coke from different parts of the car, and these two samples will be sent to the laboratory for a check analysis.

The coke will be accepted if it comes within the following limits, viz.:

Moisture, should not exceed	1.50%
Volatile matter, should not exceed	3.50%
Fixed carbon, must be above	86.00%
Sulphur, must not exceed	.75%
Ash, may range from	5.50 to 11.50%

Coke will be rejected which shows on analysis:

More than 0.85% of sulphur;
More than 0.05% of phosphorus;
Less than 85% of fixed carbon;
Less than 5% of ash.

These limits will be strictly adhered to and no concessions made in any case.

NOTE.—The Heinrich method is used for all determinations in the proximate analysis of coke, except sulphur, which is determined by Eschka's method.

When sulphur is included in an analysis, it is to be understood that the volatile matter carries one-half, and the fixed carbon the other half of the percentage due to this element.

The two following analyses of a "light" and a "strong" coke will give a good idea of our method and statement of a coke analysis.

Both of these cokes are within the limits of the specifications; No. 1 is a "light" coke, and No. 2 is a "strong" heavy coke.

	No. 1.	No. 2.
Moisture	0.33%	0.40%
Volatile matter	2.25%	1.31%
Fixed carbon	90.54%	87.46%
Sulphur	.80%	.72%
Ash	6.28%	10.02%
Structure, cells	52.94%	50.04%
Structure, coke	47.06%	49.96%
Specific gravity	1.097%	1.89%
Heat units (per lb.)	13,540.0	12,937.0

No. 1 is a light coke with medium porosity, and will give a quick intense heat.

No. 2 is a strong coke, and will hold up a heavier burden of iron; the porosity is lower (i.e., the coke is more dense), consequently a stronger blast is required.

A strong, heavy coke will give a steady continued heat.

No. 276.—Specifications for Machinery Scrap.

Under this specification we desire a good clean scrap iron, such as agricultural implements and light machinery scrap.

The scrap must contain no wrought iron, steel, stove plate, grate bars, car wheels, brake shoes, chilled roll, etc.

Malleable scrap is objectionable, also excess of oxide or rust.

Large pieces, weighing more than 400 lbs., will not be accepted.

When a car of scrap is received, the inspector will superintend the unloading, and discard the following objectionable scrap, viz.:

Wrought iron, steel, burnt stove plate, grate bars, car wheels, brakeshoes, large chilled work, burnt malleables, and large pieces weighing more than 400 lbs.

Rejected scrap will be deducted from the total weight of scrap received, and payment made only on accepted material.

No. 298.—Specifications for Molding Sand.

Sand purchased under this specification must be reasonably free from stones, dirt, silt, and organic matter, such as roots, decomposed vegetation, etc.

Three kinds of sand will be considered, viz.: Silica or fire sand; molding sand and core sand. These sands will be classified according to their chemical composition, and graded, according to the degree of fineness, into five distinct grades or numbers as follows:

Grade.	Deg. of fineness.
No. 1. Superfine	Above 100%
No. 2. Fine or light	100 to 90%
No. 3. Medium	90 " 75%
No. 4. Coarse or heavy	75 " 55%
No. 5. Extra coarse	55 " 30%

In specifying the fineness of sand, the above numbers will be used, and will apply to silica, molding, and core sand.

No sand will be accepted which varies more than 5% from the grade designated at the time of purchase.

SILICA OR FIRE SAND.—This material is used for refractory work, tempering high bond molding sand, mixing with fire clay, for steel casting purposes, and for grinding.

Good fire sand will usually run about 98% of silica, with very little alumina, lime, magnesia, or combined water, and not more than a mere trace of iron.

No fire sand will be accepted which shows, on analysis, less than 95% of silica, more than 4% of alumina, or more than 1% of lime.

The following analysis of an average fire sand will give some idea as to what is desired.

Silica (SiO_2)	98.04%
Alumina (Al_2O_3)	1.40%
Iron (Fe_2O_3)	.06%
Lime (CaO)	.20%
Magnesia (MgO)	.16%
Combined water (H_2O)	.14%
Specific gravity	2.592

MOLDING SAND.—Molding sand for iron work generally contains from 75 to 85% of silica, 5 to 13% of alumina, usually less than 2.5% of lime and magnesia, not over 0.75% of fixed alkali (soda and potash), generally less than 5% of iron, and seldom more than 4% of combined water.

Sand for brass molding may contain a much higher percentage of iron and lime, without doing any particular harm.

All molding sands usually contain some organic matter, generally present in the form of small roots or as decomposed vegetable matter.

We do not expect to buy sand with an exact chemical composition, as this is almost an impossibility, the same bed of sand often varying several per cent. in silica and alumina at different places; we do, however, reserve the

right to reject any sand not of the required degree of fineness, or that contains an excessive amount of carbonate of lime, magnesia, iron and organic matter. Our limit for the objectionable elements is as follows:

Carbonate of lime must not exceed 1.50% in an iron molding sand, and should not exceed 2.25% in a brass sand;

Iron must not exceed 5.50% in the iron molding sand, or 7% in a brass sand;

Organic matter must not exceed 1%, and preference will be given sand running lower in organic matter.

Clay and silt are objectionable, consequently any sand showing on analysis more than 13% of alumina will be rejected. (See note.)

The following analyses of molding sand will give some idea as to their chemical composition:

	Kind of work—Iron, Light.	Iron, Medium.	Iron, Heavy.	Brass, Light.
Silica (SiO_2)	82.21	85.85	88.40	78.86
Alumina (Al_2O_3)	9.48	8.27	6.30	7.89
Iron oxide (Fe_2O_3)	4.25	2.32	2.00	5.45
Lime oxide (CaO)	....	.50	.78	.50
Lime carbonate ($CaCO_3$)	.68	.29	...	1.46
Magnesia (MgO)	.32	.81	.50	1.18
Soda (Na_2O)	.09	.10	...	.13
Potash (K_2O)	.05	.03	...	.09
Manganese (MnO)	...	Trace.	.25	Trace.
Combined water (H_2O)	2.64	1.68	1.73	3.80
Organic matter	.28	.15	.04	.64
Specific gravity	2.652	2.645	2.630	2.640
Degree of fineness	85.18	66.01	46.86	94.88

So far as the chemical composition is concerned, any one of the above sands would answer fairly well for nearly any class of work, but it is absolutely necessary that the proper degree of fineness be carefully considered.

CORE SAND.—The quality, or chemical composition of a core sand, according to some authorities is of minor importance, the degree of fineness being the main feature.

As a rule, a good core sand should be high in silica and low in alumina.

The bond for core sand is obtained by adding rosin, flour, etc., consequently the desired effect is produced with a high silica sand, or with a sand low in alumina and iron.

A sand low in alumina and iron will permit of the rapid escape of the gases, whereas a high alumina or a clay sand bakes and holds back the gases.

The two following analyses, although radically different, are good core sands, due entirely to low alumina and iron:

	Core sand—Extra quality.	Fair quality.
Silica (SiO_2)	94.30	69.31
Alumina (Al_2O_3)	1.95	4.76
Iron oxide (Fe_2O_3)	.33	1.58
Lime carbonate ($CaCO_3$)	1.63	3.50
Lime sulphat. ($CaSO_4$)	....	8.19
Magnesia (MgO)	.54	7.77
Alkalies (Na_2O, K_2O)	.05	.12
Combined water (H_2O)	1.05	2.95
Organic matter	.15	1.82

Objection will be made to core sand containing more than 5% of alumina, or more than 2.5% of iron.

When a shipment of sand is received, the inspector will select three samples of about 2 lbs. each, from different parts of the car, and these samples will be sent to the laboratory for examination.

The sand after being thoroughly mixed by machinery, will first be weighed, then dried at a temperature of 220° F., for 1 hour, or until perfectly free from moisture; the difference or loss in weight, of the moist sand and the dry sample will represent the amount of moisture present.

The degree of fineness and the chemical analysis are to be determined by the dry sample.

The apparatus required for estimating the percentage or degree of fineness, consists of a scale or balance sensitive to 1 cm. or a tenth of a grain, and a set of 5-in. U. S. standard brass sieves of the following mesh, viz.: 100, 80, 60, 40 and 20.

These sieves are fitted with a cover and a bottom pan, and may be used separately or in combination; they may be obtained of any dealer in chemical apparatus.

METHOD OF DETERMINING THE DEGREE OF FINENESS OF SAND.

Exactly, 100 grams (or, if preferred, 1,000 grains) is carefully weighed out and emptied into the 100 mesh sieve, which has been previously placed upon the bottom pan.

The sieve is now shaken for exactly 1 min., mostly sidewise, but occasionally up and down to free the meshes of sand; at the end of 1 min. the bottom pan is removed, the sand weighed that has passed through, and the weight credited to the 100 mesh sieve.

The sand remaining on the 100 mesh sieve is then emptied into the 80 mesh sieve placed upon the bottom pan as before and the sieve just used is thoroughly cleaned with a stiff stencil brush.

The 80 mesh sieve is shaken as before for exactly 1 min. and the sand which has passed through is carefully weighed and credited to the 80 mesh grade. In similar manner 60, 40 and 20 mesh sieves are used each receiving credit respectively.

The amount of sand passing through the sieve, multiplied by the number of the mesh, and the sum of the several results divided by 100, will give the average per cent. or degree of fineness of the sample.

Usually there is a small loss, due to dust and to small particles of sand remaining in the meshes.

Using a set of sieves as described above, the average mesh of the series will be 60, consequently any loss sustained should be multiplied by this figure and added to the total amount.

In case there should be some coarse material remaining on the 20 mesh sieve it is weighed and credited to a No. 1 mesh.

The following example will more clearly illustrate the method and calculations:

Weight, sand passing through.		No. or mesh of sieve.			Total.
55.22	grams,	× 100	mesh	=	5,522.00
20.89	"	× 80	"	=	1,671.20
11.64	"	× 60	"	=	698.40
10.57	"	× 40	"	=	422.80
1.20	"	× 20	"	=	24.00
.06	"	× 1	"	=	.06
99.58					
.42	(loss)	× 60	"	=	25.20
					8,363.66

8,363.66 ÷ 100 = 83.64%

which is assumed to be the correct degree of fineness.

In cases of dispute it is customary to make duplicate determinations of the degree of fineness, and take the average as an absolute figure.

If the test is carefully carried out there should be very little loss, and duplicate determinations should not vary more than 2%.

NOTES ON SAND.

The following remarks on the effect of certain elements in sand will give some idea as to what is desired, and to what is considered objectionable.

SILICA is the fire-resisting element; it has no bond, i.e., binding property, consequently in a sand where adhesiveness is required, alumina must be present; silica alone is very refractory, but, in the presence of the fluxing elements, iron, lime, magnesia, soda and potash, it readily fuses and forms silicates; these silicates fuse or melt at about the following temperatures:

Silicate of alumina melts at	.....	4,350° F.
" " magnesia " "	.....	3,960° F.
" " lime " "	.....	3,810° F.
" " iron " "	.....	3,270° F.
" " soda " "	.....	1,500° F.

When soda or potash is present, silicates are formed at low temperatures.

Iron melts at 2,200 to 2,800° F., consequently a sand containing much iron, lime and alkali, will burn or fuse into the molten metal, when molding, or in other words, the more lime or alkali present the more easily the sand is converted into a slag.

ALUMINA is the binder, hence a sand high in alumina is said to be strong or possess "bond;" alumina is very refractory, but unlike silica, it "bakes together" like pottery at a high temperature, consequently too much alumina must not be present in sand, otherwise the mold would be spoiled by excessive shrinkage or by the sand being non-porous.

LIME may exist in sand as oxide, hydrate, carbonate or as sulphate, occasionally in two different forms, but usually as carbonate and oxide; the carbonate is the most objectionable form, as on heating, the carbonic acid gas is driven off, producing an excess of gas and reducing the original volume of sand.

Most of the lime salts are converted into oxide on burning, consequently excess of lime will cause a mold to either drop or crumble.

IRON may be present as ferrous oxide, ferric oxide, hydroxide, or as ferrous carbonate, all of which are converted into ferric oxide by heat. Iron in the presence of silica, alumina, lime, magnesia, etc., has a tendency to fuse or produce a slag by reduction.

MANGANESE in sand acts in a similar manner to iron, but not in such an energetic manner on account of its high fusion point.

MAGNESIA is very similar to lime, but less harmful on account of being more refractory.

ORGANIC MATTER gives bond to sand, but the bond or binding property is destroyed the moment it comes in contact with the molten metal, the organic matter being burned out; consequently, there is a loss in volume and this shrinkage causes the sand to fall or crumble.

COMBINED WATER is always present in high alumina sands, and is one reason for the shrinkage in a strong bonded sand.

The sand purchased under this specification must be within the specified limits in regard to iron, lime, and organic matter.

In buying sand, particular attention will be paid to the degree of fineness; the sand will be designated by number and must correspond to the proper degree of fineness; thus, for example, if a No. 3 molding sand is ordered, the degree of fineness must be between 75 and 90%.

The grade and number will be specified by the purchasing agent as follows:

Grade..... No.....
" ..... "
" ..... "
.....Purchasing Agent.

Specifications for Foundry Castings

No. 1.—SPECIAL HARD IRON. (CLOSE GRAINED.)

Designed for air and ammonia compressors, high-pressure engine cylinders, valves, etc.

A. CHEMICAL COMPOSITION.

Silicon must be between 1.20 and 1.60%. (Below 1.20 the metal will be too hard to machine; above 1.60 it is liable to be porous unless much scrap be used.)

Sulphur must not exceed 0.095%, and any casting showing on analysis 0.115%, or more of sulphur will be the cause for rejectment of the entire mix. (Above 0.115% sulphur produces high shrinkage, shortness, and "brittle hard" iron.)

Phosphorus should be kept below 0.70%, unless specified for special thin castings. (High phosphorus gives brittle castings, under impact.)

Manganese should not be above 0.70%, except in special chilled work.

B. PHYSICAL REQUIREMENTS.

Transverse breaking strain, with load applied at the center and supports 12 ins. apart, on a square test bar 1 in. square and 13⅛ ins. long, must stand a strain of not less than 2,400 lbs. All bars to be micrometered and figured to an exact square inch.

Deflection should not be less than 0.08-in., when taken with a standard deflectometer.

Shrinkage, measured on a 13.333-in. bar cast in a yoke, giving chilled ends, must not exceed 0.161-in., after deducting one-tenth, so as to compute the shrinkage in 12 ins.

Chill, measured on the end of a test bar cast in a yoke, should not be more than 0.25-in., except in chilled work where certain depth is required.

Tensile strength of an extra test bar cast in sand, without the yoke, must not be less than 22,000 lbs.

The casting must be free from blow-holes, slag, dirt, shot, cinder, kish and cold shuts.

A clean, close grained and strong iron is required for this class of work.

The mixture for this iron may be made from charcoal iron, low silicon foundry, home scrap, and steel scrap not to exceed 25%, or wrought scrap not to exceed 10%.

Enough scrap should be used so as to keep the graphitic carbon down low enough to produce a close grained iron.

Extra strength and greater chill may be obtained by adding from 1 to 10 lbs. of 80% ferro-manganese to every 1,000 lbs. of the charge, but should not be added unless specified.

No. 2. MEDIUM IRON.

For engine cylinders, gears, pinions, etc.

A. CHEMICAL COMPOSITION.

Silicon to be between 1.40 and 2%. (Silicon at 1.50% gives the best wearing result for gears.)

Sulphur must not exceed 0.085%, and any casting showing on analysis 0.095% or more of sulphur will be the cause for rejectment of the entire mix. (Sulphur preferred at 0.075 to 0.080%.)

Phosphorus should be kept below 0.70%, except in special work.

Manganese should be below 0.70% unless otherwise specified.

B. PHYSICAL REQUIREMENTS.

Transverse breaking strain, as described under No. 1 iron, must not be less than 2,200 lbs.

Deflection not less than 0.09-in.

Shrinkage on test bar cast in yoke must not exceed 0.151-in.

Chill should be below 0.15-in.

Tensile strength of a test bar cast in sand must be above 20,000 lbs.

The iron must be free from blow holes, shrink cavities, slag, kish, shot, cold shuts, blisters, etc.

This mixture may be made with Nos. 1, 2 or 3 foundry pig, home and foreign scrap. Total scrap should not be over 50%. For safety, in a 50% mix the foreign scrap should be figured at 0.100% for sulphur.

No. 3. SOFT IRON.

For pulleys, small castings, and general agricultural implement work.

A. CHEMICAL COMPOSITION.

Silicon must not be less than 2.20 or more than 2.80%, with a preference for about 2.40%. (Below 2.20% small castings will be very hard; above 2.80% large castings will be somewhat weak and have an open grain.)

Sulphur in no case must exceed 0.085%. (If above 0.095% the whole lot will be condemned.) High sulphur makes iron "brittle short," and causes excessive shrinkage.

For frictional wear in brakeshoes, etc., the sulphur may run up to 0.150%.

Phosphorus should be kept below 0.70%, except in cases where great fluidity is required, as in thin stove plate, when it may run up to 1.25%. (Phosphorus makes iron brittle under impact.)

Manganese should be kept below 0.70%, except in chilled work. (Manganese toughens iron, produces chill, and causes excessive shrinkage.) For a heavy chill the manganese may vary from 0.70 to 1.25%.

B. PHYSICAL REQUIREMENTS.

Transverse breaking strain must not be under 2,000 lbs.

Deflection should not be under 0.10-in.

Shrinkage must in no case be above 0.141-in. when figured to a 12-in. bar, this being equivalent to one-eighth of an inch to the foot on castings molded in sand.

Chill should be under 0.05-in.

Tensile strength on a sand cast bar must not be below 15,000 lbs.

The iron must be free from defects, such as blow holes, hot, blister, cold shuts, slag, shrink cavities, kish, contraction cracks, etc.

Misplaced cores, poor molding and insufficient cleaning will also be cause for rejectment.

This mixture may be made from Nos. 1 and 2 foundry pig, home and foreign scrap.

Scrap should be used in sufficient quantity to prevent formation of "kish" and to obtain the desired strength. It should run from 30 to 50%, being governed by the sulphur. Equal parts, or 15% home with 30% foreign scrap is a good proportion to use. Scrap or remelted iron gives strength to castings by reducing the graphitic carbon and closing the grain.

In mixing by analysis it is better to figure foreign scrap at 0.100% sulphur.

When the sulphur in the castings rises above 0.081% the percentage of scrap should be reduced in the next mix in order to regulate the sulphur. With low sulphur (0.071% about) 50% of scrap may be used.

THE SAN LEANDRO EARTH DAM OF THE OAKLAND WATER-WORKS.

By Burr Bassell.*

The San Leandro dam was commenced in 1874, and construction was continued without interruption until the latter part of 1875, when a height of 115 ft. above the bed of the creek had been attained. The reservoir then had a maximum water area of 400 acres and a capacity of 5,000,000,000 gallons. In 1898, the crest of the dam was raised 10 ft., making a height of 125 ft. above the bed of the creek. At the same time the back slope was reinforced near the crest. With water 5 ft. below the crest, as raised, the area of the water surface is 436 acres, giving a storage capacity, without sediment, of 5,826,000,000 gallons. The actual capacity at the present time is 5,167,000,000 gallons, giving a loss through silt in 26 years of 658,000,000 gallons. The drainage area of the reservoir is about 43 sq. miles.

A general plan and a cross-section of the dam are shown by the accompanying sketches. The crest of the dam is now 500 ft. long and 28 ft. wide. The original width of the ravine at the base was 66 ft. The length of the axis of the base from toe to toe of slopes is now 1,700 ft. The toe of the lower slope is 121 ft. below the high water surface of the reservoir. A puddle-filled trench was carried down 30 ft. beneath the original surface, reaching rock, except at the east end, where 20 to 30 ft. of solid clay was penetrated.

Mr. W. F. Boardman, a hydraulic engineer of Oakland, Cal., who superintended the construction of the dam, and who has kindly given me information regarding it, states that it was the original intention of the company to raise the dam 10 ft. every 4 or 5 years until it was 50 ft. higher than it is to-day, or to a height of 175 ft. above the bed of the creek, and in order to do this safely, the base of the dam was extended to the dimensions shown by the sketches. All that portion of the dam within a slope of 1 on 2½ at the rear and 1 on 3 at the face, is built of choice material, carefully selected and put in with great care. The portion outside of the 1 on 2½ slope-line at the down-stream side of the dam, was sluiced in from the adjacent hills regardless of its character, and is of ordinary soil with more or less rock.

This process of sluicing was to be carried on during the winter months, by gravity flow, when there was an abundance of water, until eventually it would fill the canyon below the dam. This would give an average slope of 1 on 6.7 at the rear. It was thought that the location was particularly favorable for this kind of construction, the original intention being to raise the dam from time to time, as already stated, not only to increase the storage as the demand for water increased, but to meet the annual loss in capacity caused by the silting up of the reservoir basin I understand that this deposit has averaged about 1 ft. in depth per annum.

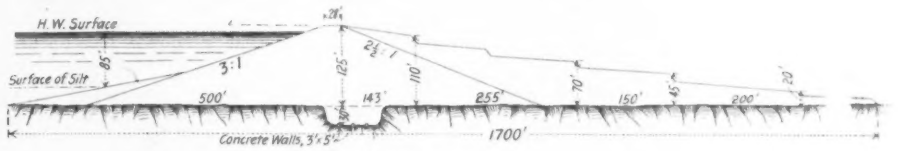
Some material was also sluiced in on the front, or wet slope, for the reason stated by Mr. Boardman, as follows:

The rocky ridge through which the upper and lower tunnels are driven is of a broken formation, some of it very hard and other portions soft, more or less broken and full of seams, and we discovered water percolating through the seams into the tunnels. It was impossible to get at the face of the slope, or find the seams, as the reservoir was full, and had it been empty we could not have found them. The only practical way was to sluice in fine clay on the face of the slope, which, under the action of the water, closed up the seams and stopped the seepage.

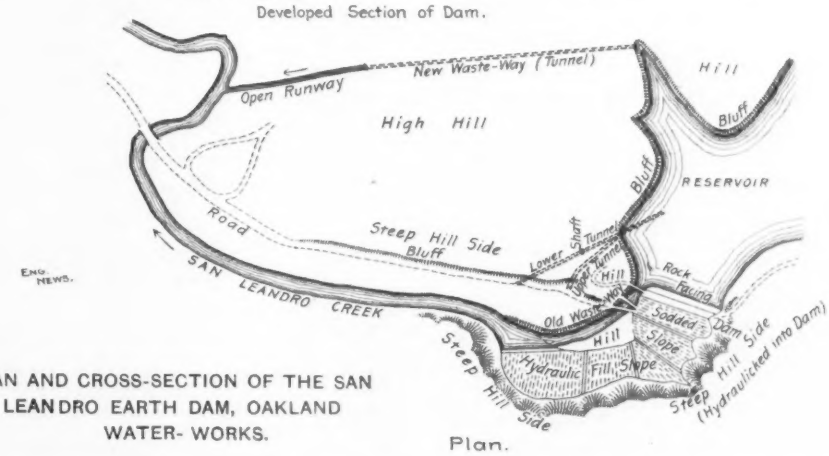
Under the main body of the dam the surface was stripped of all sediment, sand, gravel and vegetable matter. Choice material, carefully selected, was then brought in by carts and wagons and evenly distributed over the surface in layers about 1 ft. or less in thickness. This was sprinkled with just enough water to make it pack well, not enough to make it like mud.

During construction a band of horses was led by a boy on horseback over the entire work, to compact the materials and assist in making the dam one homogeneous mass. No rollers were used on this dam.

The central trench was cut 30 ft. below the original creek bed. In the bottom of this trench three secondary trenches, 3 ft. wide by 3 ft. deep, were made and filled with concrete. These concrete walls were carried up 2 ft. above the general floor of the trench to break the continuity of its surface.



Developed Section of Dam.



Plan.

PLAN AND CROSS-SECTION OF THE SAN LEANDRO EARTH DAM, OAKLAND WATER- WORKS.

The "old wasteway," shown in the sketch, while not entirely abandoned, is practically so. This wasteway is cut into the natural hillside, and is not in the best condition, although lined with masonry. The writer considers its location here a bad feature, and thinks it should be permanently closed.

The new wasteway is a tunnel about 10 × 10 ft. in section, lined with masonry throughout, having a grade of 2½%. It is 1,487 ft. long, extending through a ridge to the north of the dam.

The only criticism I will make of this tunnel is that of faulty design at the entry or reservoir end, where the water must first fall over a high spillway wall, aerating the water before entering the tunnel proper. The water even then has not easy access to the tunnel, and no adequate arrangements have been made for ventilation, so as to insure the utilization of its full capacity.

The outlet pipes are placed in two tunnels at different elevations, about as shown in the sketch There are no culverts or pipes extending through the dam itself.

Since this article was put in type some further statements regarding the San Leandro dam and reservoir, the Temescal dam, and Mr. Anthony Chabot, the founder of the Oakland water-works system, have been received. The notes, which also state Mr. Boardman's connection with the water supply of Oakland, are as follows:

The Temescal Dam was built by Mr. Anthony Chabot, in 1866, and it was after he had expended all his available capital and needed assistance that a corporation was formed. (The Contra Costa Water Co.—Ed.) This reservoir is 4½ miles north of Oakland. In 1868 it was 105 ft. above bed of creek. In 1886, the crest was raised 10 ft., so the present elevation of the crest is 115 ft. above the bed of the creek and 437 ft. above tide water of the bay of San Francisco. Slope: inside, 1 on 3; outside, 1 on 5. Area, 18 acres. Capacity, 250,000,000 gallons. Area drained by lake, 1,500 acres.

The San Leandro Reservoir is situated 8½ miles southeast from the city of Oakland. . . . This reservoir was formerly called Lake Chabot, in honor of its chief promoter, but after his death his name was dropped by the present management, and they now designate it as San Leandro Lake or reservoir.

Mr. Chabot was a man of excellent judgment, of keen, quick perception, and all honor is due him for projecting and constructing a plant founded on such broad lines. Had he lived the San Leandro Dam would have been raised from time to time until it reached the elevation, as designed, of 175 ft. above the bed of the creek.

The location of both dams, and all the surveys and construction of all tunnels, and in fact all engineering work required from the commencement of this work until the day of his (Mr. Chabot's) death on Jan. 6, 1888, was my special work. He (Mr. Chabot) employed no other engineers, except in one case: He submitted my plan for the waste tunnel to Col. Geo. H. Mendell, of the U. S. Engineers, who advised him to let Boardman construct it just as designed.

(Schuyler's "Reservoirs for Irrigation" states that the base of the San Leandro dam is 115 ft. above the tide; that the dam has a total volume of 542,700 cu. yds., of which about 160,000 were sluiced in. The method of sluicing employed is described as follows:

The water was brought four miles in a ditch, and the sluiced materials were conveyed in a flume, lined with sheet-iron plates and laid on a grade of 4 to 6%. The water used was 10 to 15 sec.-ft., and the ground-sluicing method was alone employed, as it was not convenient to get water under pressure. The cost was estimated at one-fourth to one-fifth that of putting the earth in place with carts or scrapers.

Mr. Schuyler also states that Mr. Chabot was a "practical hydraulic miner," which may explain why he adopted the hydraulic fill method for constructing a part of his dam.—Ed.)

EXPERIMENTS IN EVAPORATION FROM THE SOIL AT THE WYOMING EXPERIMENT STATION.

Experiments in soil evaporation during 1901 are reported in detail in Bulletin No. 52 of the Wyoming Agricultural Experiment Station. The station is located at Laramie, and the studies were made and are reported by Mr. C. B. Ridgway, Physicist and Meteorologist of the station.

The soil was studied in places by sinking 6-in. tubes to a depth of 26 ins., clearing away the earth sufficiently to joint a smaller water tube of about the same length to the bottom of the soil tube, and maintaining water at various depths in the water tube. The evaporation was determined by recording the amount of water required to maintain the level in the water tube, and for purposes of comparison observations were made of the evaporation from an exposed water surface in a nearby tank. The bottom of the earth tube was, of course, closed to exclude moisture from the

*Consulting Engineer, 130 Ellis St., San Francisco, Cal.

surrounding soil. The effect of stirring the soil to various depths was noted. The alkali studies were made by soaking the earth with solutions of sodium carbonate, after which ordinary well water was used in the water tube. The conclusions drawn from the experiments were as follows:

The evaporation from the surface of the soil with the level of water maintained at 6 ins. below was 95%, at 12 ins., 70%; 18 ins., 45%; 22 ins., 35% of what it was at the surface of the water in the evaporation tank.

Stirring the ground once a week to the depth of 2 ins. retarded evaporation to the amount of 19%; when stirred to a depth of 4 ins. it was retarded 23%, and when stirred to a depth of 6 ins. evaporation was retarded 45%. The water in all three of the pipes was maintained at a depth of 22 ins. below the surface of the soil.

Evaporation was retarded 43% when the soil contained 0.0597% of alkali and the level of water was maintained at 6 ins. below the surface. The amount of retardation was 55% in soil containing 0.5116% of alkali, and the level of water 12 ins. below the surface. In soil containing 0.6375% of alkali the amount of retardation was 50% when the level of water was maintained at 18 ins. below the surface; while the retardation was 57% in soil containing 0.6205% of alkali and the level of water kept at 22 ins. below the surface. The amount of alkali is the average amount found in the entire 26 ins. of soil.

More alkali was found in the first 3 ins. than in any other 3 ins. of the soil. More alkali was found in the last 2 ins. than in the 3 ins. next above.

RAILWAY COMPETITION WITH CANALS.*

There are three general causes for the decline of canals. The first is the great reduction in the rates of freight by the railroads in the United States, and notably in the State of New York. The second cause is the marvelous development of the motive power and rolling stock of American railways. Less than a quarter of a century ago, upon the average American railroad, the capacity of a freight car was 20,000 lbs.; the capacity of a freight engine was from 20 to 30 of such cars to the train.

To-day, on the New York Central, whose six tracks run alongside the Erie Canal for the entire distance from Buffalo to Albany, the capacity of the grain cars is from 60,000 to 66,000 lbs., and a locomotive of the latest type will haul from 75 to 90 such cars loaded to their full capacity. It is not an infrequent occurrence for a single engine to haul through the Mohawk Valley, beside the Erie Canal, 85,000 to 90,000 bushels of grain in a single train. When you consider that in the busy season there are from 75 to 100 such trains a day passing over the New York Central alone, you will get some conception of the situation.

The third cause for the failure of the canals is the general demand of the public for quick time.

A short time ago the Lake steamer "Abyssinia" arrived in Buffalo on a Friday evening with 40,000 bushels of grain, while the "Cevic" of the White Star Line was at her pier in New York about to sail with water for ballast, unless she could get a cargo of grain. This grain from the "Abyssinia" was quickly trans-shipped at Buffalo to the cars of the New York Central, left Buffalo Saturday evening, and was in the hold of the "Cevic" shortly after noon on Monday. The dispatch with which this grain was handled makes a record that has never been equalled by rail, and of course could not be approached by canal.

THE ENGINEERING SCHOOL AT TOKIO, JAPAN, recently graduated 201 students; of these 66 graduated in civil engineering, 30 in mechanical engineering, 22 in electrical engineering, 46 in architecture, and 18 in mining and metallurgy. Since this school was founded—27 years ago—the total number of graduates is said to be 3,324.

*From an address by Geo. H. Daniels, Gen. Pass. Agt. N. Y. C. & H. R. R. R., at Chatauqua, N. Y., Aug. 11.

DIFFICULT WORK ON THE MEUDON TUNNEL ON THE NEW RAILWAY FROM PARIS TO VERSAILLES.

In its issue of June 7, 1902, "Le Genie Civil" illustrates and describes the construction of the new railway line between Paris and Versailles, which was completed in May of this year. The difficult portion of the work lay in the 3,350-m. tunnel of Meudon, which penetrated a marl formation overlaid by water-bearing sand. The entire line is 17 km., or 10.54 miles long and the grade is a uniformly ascending one—towards Versailles, of 8 in 1,000.

The engineering interest lies in the difficulties encountered in the tunnel. At the Versailles end the contractors commenced operations with a shield similar to that employed in driving the Clichy tunnel under the Seine, and in constructing the Metropolitan Railway of Paris. But at the very beginning the pressure from the soil gave trouble; and after penetrating about 253 ft. the shield was so much deformed that it had to be abandoned, and its shell was left between the earth and the masonry.

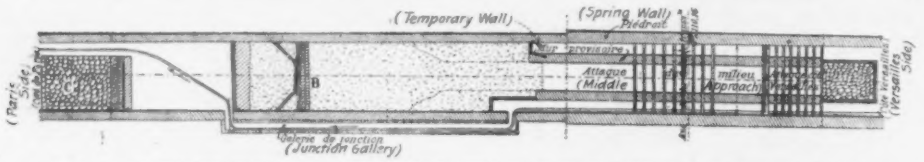


FIG. 1. PLAN OF THE CUT-OFF WALLS, ETC., AT THE POINT OF THE CAVE-IN.

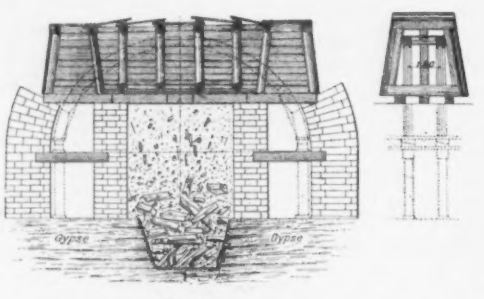


Fig. 2.

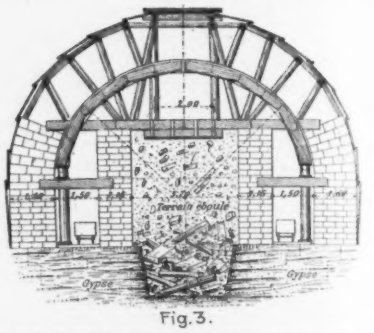
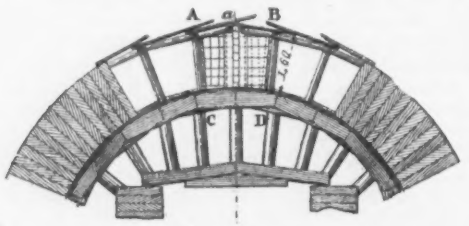


Fig. 3.

FIGS. 2 AND 3. SECTIONS, SHOWING TEMPORARY INTERIOR WALLS, AND THE TRANSVERSE GALLERY AT THE POINT OF COMMENCING ATTACK ON THE DEBRIS NEAR TOP OF TUNNEL.



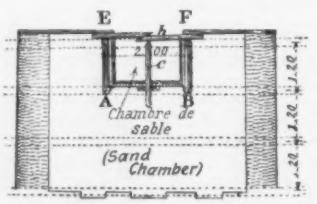


FIG. 4. DETAILS SHOWING CONSTRUCTION OF A "SAND-CHAMBER."

Work was continued in the ordinary manner; but the lack of stability in the soil demanded the most difficult and delicate timbering; water, also, began to be very troublesome. At a point 4,290 ft. from the Versailles end, the marl was encountered; this swelled on exposure to the air and the water from the upper sands filtered through it under very heavy pressure. It was difficult here to prevent the crushing of the timbering, and even of the masonry lining, which latter had been increased in thickness from 2 ft. to 5.25 ft. in some cases.

Notwithstanding the difficulties encountered the tunnel had been pushed forward until only 164 ft. of the length of the side walls, or abutments of the arch, remained to be built. But at this point, on June 26, 1900, a portion of the arch not yet supported by the side walls gave way under the pressure, and an inflow of material from above followed that cost a delay of five months and the expenditure of $200,000. A length of about 131 ft. was affected by this cave-in. It occurred at a point where the marl strata and the water-bearing sand met, very near the top of the arch, and an examination made after the run showed two principal fissures, one near each of the ends of the length affected; though some less important fissures occurred near the center of this length.

The cave-in would have had relatively little importance had it not been for the presence of quicksand immediately above the marl. The first effort of the engineers was in the direction of confining the cave-in by erecting dams across the tunnel. On the Versailles end there was little trouble; but towards Paris, a bulkhead of planks, strongly braced, was first put up; and back of this was built a masonry bulkhead, backed by sacks of cement and a mass of dry stone. This bulkhead completely shut up the tunnel, except a small passage on one side that was arranged so as to be securely and quickly closed in case of necessity. With the invasion of the remaining parts of the tunnel thus checked, the next step was to attack the cave-in from both sides; but, before this was done a small gallery was driven on one side, outside the side walls, to permit the drainage of the water by gravity towards Paris.

It was determined, in this case, to build the lower part of the arch first, and to build these in galleries; and for this purpose, and to better support the arch-centers, two temporary walls were constructed in the tunnel, as shown in Figs. 2, 3. The excavation of the galleries, between the side walls, still standing and unaffected by the cave, and the temporary walls, was executed without much trouble; and the Versailles end of the cave was soon reached. The upper part of the cave was now attacked, working in a mass of debris made up of the inrush of marl, broken masonry and quicksand. It was found that the central part of this length was made up of material relatively solid, and to which the quicksand had not penetrated; and a cross-heading was driven through this, and centers were placed for the in-

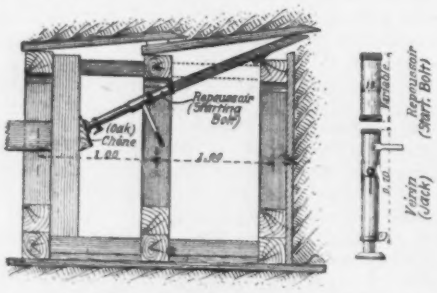


Fig. 6. Method of Forcing Beams Into Place With a 30-Ton Hydraulic Jack.

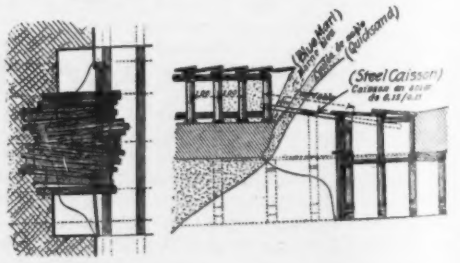


Fig. 7. Plan and Vertical Section of the "Caisson Curtain" on the Paris Side.

trados of the arch, resting upon the provisional walls and the springing of the arch. With this cross-heading and centers in place, two faces of attack were established. The building of the upper part of the arch was commenced under great difficulties, as the work had to be carried on

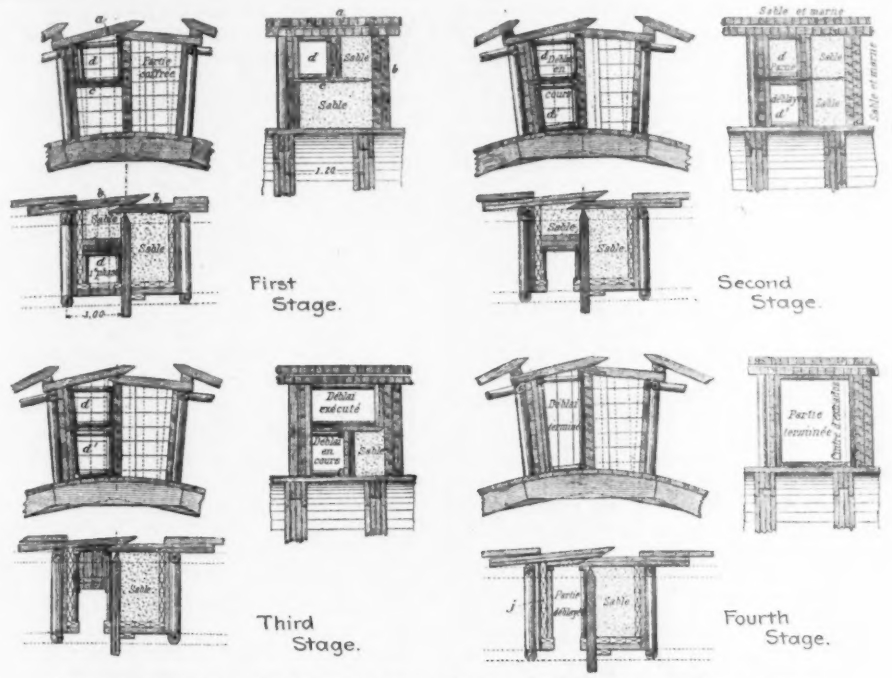


FIG. 5. THE FOUR SUCCESSIVE STAGES OF EMPTYING A SAND-CHAMBER.

a = roof on pieces 13 × 13 cm. raking and jointed; b = transverse poling boards, 13 × 13 cm., with a jog for forming timbers; c = horizontal pieces, 6 × 18 cm.; d = advance poling in pieces, 20 × 25 cm.

through the quicksand and broken material mentioned.

The fine sand, carrying a certain quantity of water, became almost fluid, and as it was under considerable pressure it would penetrate the smallest aperture. Compressed air was impracticable owing to the air pressure necessary to withstand the pressure of the soil; and the freezing process could not be employed because it was impossible to drive the pipes horizontally through the masses of stone masonry imbedded in the sand. The engineers, therefore, resorted to what they called "sand-chambers" as a means of excavating through an almost fluid sand under an enormous pressure.

This novel process is thus described: The advance was made in a concave form, and this advance was maintained by a system of poling-boards and boxes, completely stopping off the face of the advance. This was done by making a double wall of horizontal and vertical squared sticks (Fig. 4) as closely jointed as possible, and with the joints sometimes calked. The size of this chamber varied with the necessity of the case, as shown in Fig. 5; and if the contents much exceeded a cubic meter, it was cut into a series of smaller chambers. In cutting up a chamber the following process was followed, referring to Fig. 4. Let A B C D, A B E F represent the elevation and plan of a chamber that is to be cut into eight parts. This main chamber is first

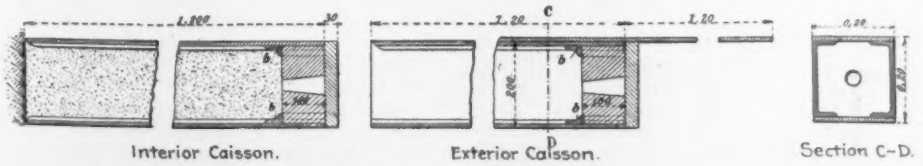


FIG. 9. DETAIL OF METAL BEAMS, OR "CAISSONS," AT VERSAILLES END.

divided into two parts by the vertical wall C, and then each half is divided into four parts by horizontal and vertical walls, as seen in Fig. 5. To put in these divisions without opening the sides of the main chamber, each division wall is made of squared timbers, about 6 ins. on a side, forced successively through holes previously outlined by boring a series of small holes through the poling-boards, the beam driving ahead of it the block of wood thus cut away. In this manner one stick was laid on the other, or by the side of another, as the wall was vertical or horizontal in position. The placing of these sticks, however, was very difficult, requiring 20 and 30-ton hydraulic jacks to force them in. In some cases beams bored out on the axis were used, thus decreasing the pressure by permitting a flow of sand and water through the beam. Towards the end of the work the resistance became so great that iron beams imbedded in wood were used along with 70-ton jacks.

When a chamber not exceeding one cubic meter in capacity was thus secured, it was emptied of sand. But this operation consumed the larger part of the time and was conducted progressively. Even with the greatest exercise of care, the division-walls were more or less well jointed, and the quicksand invaded the secondary chambers; and to avoid runs of the quicksand, as soon as one beam had been taken away and a little of the sand behind it removed, this beam was put back before another was removed for a similar purpose. In Fig. 5 we have shown the four successive stages of emptying the sand-chamber, or the emptying of the four secondary chambers in a half main chamber. As showing the difficulty and danger and the delicate nature of the work required, it is only necessary to say that the advance was made as the average rate of one small chamber emptied per week; or it took that time to remove a cu. m. of sand. Thanks to the extreme precautions taken, no workman met with an accident resulting from the inflow of the sand; but there was almost constant leakage through the poling-board faces.

At the ends of the cave-in, or near the ends of the crushed arch, special processes had to be employed to clear the sand. Here a curtain of so-called "caissons" was resorted to, as shown in Fig. 6. After having excavated by the methods described along the top of the tunnel to within about 2 m. of the portion of the masonry not affected by the cave-in, it was decided to construct a kind of metallic roof, starting from the top of the advance gallery and extending to the top of the arch still in place. This roof was made up of a series of metal "caissons," each 3 m. long by 15 cm. square, placed one alongside the other and pushed forward by a 70-ton ram. This was accomplished after much trouble.

On the Versailles side, the connection was made by a gallery run transverse to the axis of the tunnel. The attack on the sandy portion was made by a series of similar metal beam-caissons; but these were 20 cm. square and only 1.20 m long, pushed in place by a 30-ton ram, as shown in Fig. 7. The rear of these caissons was provided with holes, through which the more or less fluid sand escaped, and which could be stopped by a plug at any time. This arrangement decreased the pressure encountered. The caissons forming the lateral sides and the top of the battery were provided in the rear with a pushing-stick of the same dimensions, which formed the sides and top of the chamber made and shielded it from the sand.

The arch as built was 5.24 ft. thick, but even this great thickness did not prevent the infiltration of water under the enormous pressure. Holes were cut through the masonry and cement grout was injected; but this did not remedy the evil, and it was decided to put a waterproof lining on the inside of the arch. This was made of a layer of cement mortar, followed by rings of galvanized steel, with a lining of concrete-steel holding the other two in place. The steel lining was 1 mm. thick, in sheets 1 m. wide by 2 m. long, and

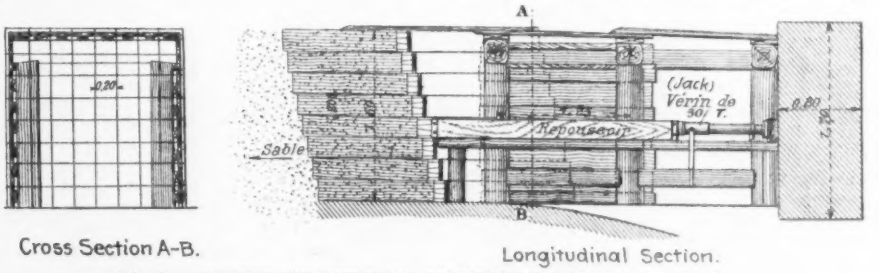


FIG. 8. METHOD OF BUILDING CAISSON AT VERSAILLES END.

soldered at the edges so as to make a tight joint; this sheet was secured to oak pegs driven in the masonry. A space 4 cm. wide was left between a ring of the steel and the masonry, and this space was filled with injected cement mortar. And, finally, to secure this skin of steel and cement against the pressure from outside, concrete-steel was used as the only material able to offer sufficient resistance in a limited depth. Before the sheet steel was put in place a series of bolts, 40 to 70 cm. long, had been set in the masonry with cement, and to these bolts the outer skin was secured, the thickness of the latter being 35 cm. at the crown, decreasing to 20 cm. at the springing lines, and again increasing to 30 cm. at the base of the sidewalls. The grillage used was made up of longitudinal round rods 20 mm. diameter on transverse rods 45 mm. diameter, with a diagonal system of 6 mm. steel wire, meeting at the crossing points of the layer rods. The concrete was made of Portland cement and gravel, very carefully rammed.

Notwithstanding the excessive cost of the rebuilding of the 131 ft. affected by the cave-in, which was about $15.25 per lineal foot, the entire cost of the Meudon Tunnel was only about $2,000,000, or less than $914 per foot.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, - - - TREASURER AND BUSINESS MANAGER.

WM. KENT, E. E. R. TRATMAN, M. N. BAKER, CHAS. S. HILL, } ASSOCIATE EDITORS.

A. B. GILBERT, - - - - - - - - ASSISTANT MANAGER.

CHAS. W. REINHARDT, - - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston,
} ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 means that subscription is paid to the 32d week (that is the issue of Aug. 6) of the year 1903; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

In the recent discussion of proposed changes in the New Croton Dam a number of engineers assumed that the maximum height yet attained by earth dams was 70 to 80 ft. A little investigation would have shown that there were several in existence exceeding 100 ft. in height, but, strange to say, no adequate description of any of these could have been found at that time. Selecting the highest one of which we then had knowledge, the Druid Lake Dam, at Baltimore, Md., we were fortunate enough to obtain an illustrated description of it, which we published in our issue of Feb. 20, 1902. It is 100⅓ ft. high from the crest to the natural ground surface, and 118⅝ ft. to the rock beneath the heart-wall. Water for filling the reservoir permanently was first admitted on Jan. 2, 1871. Elsewhere in this issue there is given a description of another high earth dam, originally built in 1874-5, but since raised to a height of 125 ft. above the original surface, 155 ft. above the bottom of the central puddle trench, and 158 ft. above the bottom of the concrete-filled secondary trenches. This structure is the San Leandro Dam, of the water-works of Oakland, Cal., and is particularly interesting because a large part of the embankment was sluiced in by the hydraulic process. The dam was projected for an ultimate height of 175 ft. above the natural surface. In our issue of July 10, 1902, there appeared a description of a new earth dam near Jackson, Cal., the embankment of which was completed on Dec. 14, 1901. This, known as the Tabeaud Dam, has its crest 110 ft. above the natural surface, and 120 ft. above rock foundation.

In the discussion on the earth portion of the New Croton Dam the difference in elevation between the water surface and the intersection of the lower slope of the dam with the natural ground surface was used, for comparative purposes, as the effective height of a dam. On this basis the effective height of the Druid Lake Dam is 95⅓ ft.; Tabeaud, 115 ft.; San Leandro, 121 ft.

The three dams already named by no means exhaust the list of structures over 100 ft. high, for the article on the San Leandro Dam, elsewhere in this issue, contains a brief description of a second dam connected with the Oakland water supply, built to a height of 105 ft. above the natural surface so long ago as 1866, and raised to 115 ft. in 1886. Close onto 100 ft. in height are the Pliarcitos Dam, 95 ft., and the San Andreas Dam, 93 ft., built many years ago by the Spring Valley Water-Works Co., of San Francisco. With the exception of the Druid Lake Dam, at Baltimore, all these high earth structures are in California, and may be considered as forerunners of the bold work in long distance electrical transmission which is making the Pacific Coast notable in these later days.

The intimate connection of railway transportation facilities with the business and industrial situation is well illustrated by the statement that increase in iron and steel production to keep pace with demand is dependent on the ability of the railways to haul sufficient coke to supply the blast furnaces. The railways handling this traffic are said to be short of cars, of yard room and of locomotive capacity to handle the business, and this notwithstanding the fact that they have been for a year or two past actively engaged in increasing both their rolling stock equipment and their track capacity.

At present this lack of coke is seriously curtailing the output of pig iron, and since that is the raw material for every other branch of the iron and steel industry, the effect is bound to be felt in a diminished supply of finished iron and steel products. Were it not for this shortage of transportation facilities, the outlook would be promising that production in many departments of iron and steel production would exceed the demand at no distant date. Already in the tin plate and wire industries many mills are idle for lack of business, and it is noteworthy that in the latter industry particularly, the surplus of supply can be directly traced to the building of numerous new works after the absorption of the bulk of the existing plants by the United States Steel Corporation. In many other branches of the steel industry, new works started during the past year or so are now approaching completion. The addition of their output to the present market can hardly fail to have an effect in bettering conditions of delivery and making prices easier. Of course, this is on the supposition that they are able to obtain necessary supplies of raw material, but it is inconceivable that the railways handling coal and coke will not be able in a short time to take care of the traffic demands upon them.

In any forecasting of the market, too, the possibility or probability of a slacking in demand must be borne in mind. This is very well put by Mr. J. S. Jeans, of the British Iron Trade Association, in his recent work on American industrial conditions:

> We are apt to forget that it is not more than eight years since the pig-iron consumption of the United States fell to little over seven million tons a year, or considerably less than one-half of that of to-day. If a productive capacity of 24,000,000 to 26,000,000 tons of pig-iron were brought face to face with a demand for only one-third of that quantity, with a corresponding relation of demand to capacity in all other branches of the iron and steel industries, some strange things would be likely to happen.

The need of a greater number of rainfall observing stations and of more accurate observations at many of those already in existence, will be obvious to anyone who reads the symposium on "Rainfall and Charts of Rainfall" in the U. S. "Monthly Weather Review" for April, 1902. Letters and extracts from the writings of many eminent meteorologists and other scientists are presented with the aim of throwing light on the best methods of preparing rainfall maps or charts. The symposium, however, covers many phases of rainfall records, besides including records of the average annual precipitation for 734 stations in the United States for the period 1871-1901, compiled by Prof. Alfred C. Henry. Of these stations, 140 had records for 30 years or more; 183 for 20 to 30 years; 329 for 10 to 20 years; and 82 for periods of less than 10 years. The weather report for April, it may be stated, contains observations from 3,100 stations, mostly in the United States and Canada, but a large proportion of the stations in this country have been established but a few years. The 734 stations included in Professor Henry's record, if uniformly distributed, would be 65 miles apart and represent an area of about 4,100 sq. miles each; but in the more thickly settled parts of the country the stations average about one to 2,500 sq. miles, and "in the sparsely populated regions a single station sometimes represents an area of as much as 16,000 sq. miles, although the average is much less." Besides the shortness of the periods of observation at many stations, and the immense areas in portions of the country still without observers, the symposium brings out the serious deficiency due to there being comparatively few stations at high elevations.

It should be understood that the value of the Weather Bureau observations on rainfall are by no means to be judged from their relation to a satisfactory rainfall map of the whole country. To engineers, as a whole, the local observations, covering as they do maximum rainfalls for single storms and very short intervals, as well as monthly and yearly periods, are of far more importance than the results for the whole country, or even a single State. It is nevertheless true that, with the exception of a comparatively few sections, the government rainfall records are so scanty as not to afford sufficient data for the study of precipitation over whole drainage areas. This is particularly true of the mountainous regions, and of all sparsely settled territory. In April, 1902, the regular Weather Bureau stations numbered but 162, against 2,562 served by voluntary observers (the balance being served by other government departments and the Southern Pacific Railway, or being located in foreign countries). It is only fair to add that the Weather Bureau is doubtless extending its regular service as rapidly, and is inspecting the volunteer service as thoroughly, as its funds will permit.

A legal decision worth notice by those who advocate making engineering a "close" profession by legislation was recently rendered by the Illinois Supreme Court. In 1897 a law was enacted in Illinois forbidding "any person to practice as a horseshoer in the State without a license." The Supreme Court has now declared this law to be unconstitutional. In the decision is quoted the sentence from the Declaration of Independence which affirms "life, liberty and the pursuit of happiness" to be among the inalienable rights of man. In a Louisiana decision it was said that "the liberty of pursuit, the right to follow any of the ordinary callings of life, is one of the privileges of a citizen of the United States." The law-making power cannot infringe this privilege without sufficient cause; and the Illinois court concludes:

> It is impossible to conceive how the health, comfort, safety or welfare of society is to be promoted by requiring a horseshoer to practice the business of horseshoeing for four years, and submit to an examination by a board of examiners and pay a license fee for the privilege of exercising his calling.

The publication of the proceedings of a technical society, comprising 363 pages, and containing numerous illustrations, within less than three months of its annual convention is a notable action in view of the usual delays in such matters. This has just been accomplished by the American Water-Works Association, and by so doing the value of its proceedings has been greatly increased. The report contains many interesting papers, and while the discussion of some of the most important of these is limited or practically lacking some of the topics presented brought out a good round of ideas and experience. With this action as a forerunner, and with the steps taken at the Chicago meeting to advance its interests, the future of the association looks brighter than for a number of years past. Mr. J. M. Diven, of Elmira, N. Y., is secretary of the association, and should be given credit for the enterprise commended above.

The report of a well-known consulting engineer on the garbage cremation plant at Trenton, N. J., which is printed in this issue, deserves the atten-

tion of engineers, city officials and all interested in the improvement of municipal conditions.

In brief, the city of Trenton some time ago constructed a garbage crematory with little or no regard for engineering principles, and apparently in profound ignorance of the present state of the art of garbage cremation. When the plant was put in operation it gave very unsatisfactory results, and the city finally did last what it ought to have done first, sought competent engineering advice.

It is high time that American municipalities should recognize that garbage disposal, like water supply and sewerage, is really a work in which success can only be ensured by the employment of competent engineers. It is high time, too, that the practice of making garbage disposal a matter of local politics—not seldom with perquisites attached—should come to an end. Even where politics has not controlled the award of garbage contracts and where there has been an attempt to proceed in a businesslike manner, the need of expert advice has been overlooked. American cities and American builders of garbage cremation furnaces have alike, with rare exceptions, proceeded in sublime ignorance of the essential principles of sanitary and economical garbage cremation.

The report on conditions at Trenton, as we have said elsewhere, is the first example of a thorough engineering study of an American garbage disposal plant which has come to our attention. Now that Trenton has led the way, we trust that other cities which have been wasting money and conducting litigation over unsuccessful garbage works will see the advantage of engaging expert advice.

The Brooklyn "Eagle" is another daily newspaper that stands in need of an engineering editor. It goes far out of its way to criticise the proposed discharge of the Passaic Valley sewage into deep water in New York Harbor at a time when its own borough officials are spending hundreds of thousands of dollars on trunk sewers discharging at the bulkhead line. Besides this, it attempts to add force to its criticism by inveighing against the waste of valuable fertilizing material in much the same strain as "Boston Transcript," a quotation from which is given in our correspondence columns. We have commented at some length in those columns on the fallacy of such ideas.

The recent death of a party of Alpine mountain climbers by a lightning stroke has given rise to considerable discussion in foreign journals as to what precautions one should take to minimize the risk if caught in a thunder-storm. There appears to be a general assumption that the risk of injury by lightning is greater on a mountain than in low lands; but we know of no facts to support this. Accidents to mountain climbers are more apt to be widely published, and to this very likely is due the idea that lightning strokes are more frequent at high altitudes.

The discussion has extended to the precautions which should be taken by one caught in a thunder-storm in the open country. That it increases the danger to take refuge under isolated trees is well known, and the "London Electrician" remarks that "experts" have recommended as the safest plan to get wet through and lie down in the middle of a field. "We should think it safer," says "The Electrician," "to go home and get dry. There are more deaths caused by rheumatic fever than by lightning strokes."

THE NEW YORK BARGE CANAL PROJECT AGAIN.

The proposed 1,000-ton barge canal across the State of New York, which has been before the New York legislature at two successive sessions, and each time has failed to receive favorable action, is to be brought forward again when the legislature reassembles after the beginning of the new year. The Canal Association of Greater New York—a sort of confederation of various commercial organizations of New York city—has had a committee at work for some time studying the merits of the various routes proposed for such a canal, and this committee has just rendered a report.

As many of our readers will remember, the elaborate survey for this canal made under direction of the State Engineer of New York in 1900 covered a number of alternative routes, and the canal advocates have had much difficulty in agreeing as to which route they should favor. The chief question, however, is as to whether the route should be via Lake Ontario or straight across the State in substantially the present location of the Erie Canal. The committee above referred to has now reported against the Ontario route, and its reasons for rejecting it seem worth putting on record. We therefore print them, as follows:

1. The type of vessel constructed for navigation on the Lakes is of a different character from that of vessels designed exclusively for canal and river navigation, and the cost of construction of such vessels as are capable of navigating Lake Ontario as well as the canals would be considerably enhanced, in the case of wooden vessels at least 50%, thus very materially increasing the interest charge on such vessels.

2. The construction of vessels capable of navigating Lake Ontario as well as the canals, being of a different type and heavier in character would necessarily involve a loss in carrying capacity of at least 20%, if not more. In fact, it is the opinion of competent shipbuilders that it would hardly seem practicable to operate a line of vessels properly constructed for both lake and canal work.

3. The expense of maintenance and operation of such vessels would be greater, the running expenses being considerably higher.

4. The type of canal transportation that has proved most economical at the present time is a fleet of three or more barges propelled by a steam vessel, itself capable of carrying cargo. Such a steam vessel to be capable of towing this canal fleet of three barges through Lake Ontario at all seasons must necessarily be of considerably greater power than the ordinary steamship in use for canal purposes; in fact, it appears doubtful if another type of lake towing vessel or tug would not appear necessary for use on Lake Ontario. This would alter the conditions under which canal barges could be continuously towed from Buffalo to New York, involving additional expense and other complications.

5. The weather during the early spring and late fall on Lake Ontario is such as to render it doubtful if tows of canal barges deeply laden could leave the ports of Olcott and Oswego, respectively, at these seasons of the year with regularity, and the probability is that frequent delay would be encountered through this season.

6. The question of additional insurance during the stormy season on Lake Ontario would be another factor of expense.

7. The adoption of the Ontario route would deprive that part of the state between Lockport and Syracuse of the benefits expected to result from an improved and enlarged waterway.

8. The opening of another waterway from Lake Erie into Lake Ontario might give rise to apprehension that Western products would thereby be given another outlet through the St. Lawrence.

Your sub-committee, after full consideration, unhesitatingly affirm their conviction that the Oneida-Seneca route constitutes the most practical, the most efficient and the most economical route for a 1,000-ton barge canal between the Great Lakes and the Hudson River.

(Signed) Gustav H. Schwab, Frank Brainard, Henry B. Hebert, Wm. R. Corwine, Committee.

Let us see what the principal features are of the two routes which the committee has compared. Turning to the report of the New York State Engineer for 1901, we find that the estimated cost of construction of a canal by the two routes is, for the present Erie Canal route, $70,323,000, and for the route via Lake Ontario, $44,812,000. Thus the Lake Ontario route will cost $25,500,000 less than the other to construct. This means a smaller yearly interest charge on the State Treasury of $765,000 (assuming 3% interest). Besides this, the Ontario route will be far cheaper to maintain than the inland route. The distance from the Hudson River to Buffalo by the two routes is substantially the same; but the Ontario route has 112 miles of open lake navigation, which costs nothing for maintenance, as compared with an equal length of artificial canal on the other route which must be continuously maintained. It is therefore clear that the Ontario route would not only cost the State twenty-five and a half million dollars less to build, but at least a million and a half dollars a year less to take care of.

There is another advantage of the Ontario route. Vessels could go from Troy to Buffalo and return by it in 35 to 40 hours less time, or, in other words, according to the engineers' estimates, nearly 20% longer time will be required for a voyage via the inland, all-canal, route than for a voyage via the Ontario route.

These are certainly very important and undeniable advantages of the Ontario route. Now, let us analyze the reasons which the committee give for rejecting it. We will take them up seriatim:

(1 and 2) We have no doubt that with the present type of Erie Canal boats, a very much stancher vessel would be required for Lake navigation than those which are now used on the placid waters of the canal. But with barges of 10 ft. draft, 25 ft. beam and 150 ft. length, which the proposed canal is to accommodate, we seriously question whether any such great difference would be found. The weakness of the committee's position is suggested by their solemn statement that wooden vessels for combined lake and canal service would cost at least 50% more than for canal service alone. The fact is that by the time any barge canal is completed, wooden vessels for service as 1,000-ton barges will probably be as obsolete as Noah's Ark. The successful operation of steel canal boats on the present Erie Canal and running from Buffalo to Cleveland on Lake Erie is well known. If this is feasible with the present shallow canal, it will be much more feasible with the deeper canal, and much larger boats now proposed to be built for service upon it. Even should the inland route be adopted for the canal, a large proportion of the barges to ply upon it would in all probability be built seaworthy enough for Lake service, because they would then be able to go without breaking bulk to ports on Lake Erie and the Detroit River, and also to ports on Long Island Sound.

(3 and 4) Admitting, for the sake of argument, that the future 1,000-ton barge must be built with heavier plates and framing if she is to ply on the lake as well as the canal, it does not at all follow that her cost of maintenance and operation will be greater. On the contrary, the stancher, stiffer vessel should cost less to keep in repair. It is true that greater power will very likely be required for towing at proper speed through the lake than in the canal; but this presents no obstacle. Heavy tugs would doubtless make a business of moving canal tows on the lake, and competition would keep the rate down to a reasonable figure.

(5 and 6) Severe storms on Lake Ontario would necessitate delays in port; but the time a boat would lose in this way in a season may be fairly offset against the loss of time on every trip by the longer inland route, amounting, as already shown, to 20% of the total voyage.

(7) The great argument for a 1,000-ton barge canal has been the through traffic it was expected to handle; and the Ontario route can accommodate this as well as the inland route. The local traffic between Lockport and Syracuse can be taken care of by the present Erie Canal. It would be absurd to ask the State to spend an additional twenty-five million dollars for this alone.

(8) The St. Lawrence route to the sea is a bugbear; and if it were anything more, the proposed canal from Lockport to Olcott would not be of any importance to its success.

Finally, while we see no prospect that the New York legislature can be induced to favor or the people to confirm the 1,000-ton barge canal enterprise in any form, the selection of the seventy-million-dollar route by the canal advocates makes doubly sure the failure of the scheme.

If the 1,000-ton barge canal can do all its advocates claim, it can do it practically as well if built on the route costing only $45,000,000 as on the one costing $70,000,000. If the canal should be built on the Ontario route and prove a success, and it should then be deemed worth while to complete the inland route from Syracuse to Lockport, that can then be undertaken and carried through at little greater total expense to the State than if that route had been adopted in the first place.

To sum the whole matter up: The proposed 1,000-ton barge canal is a huge experiment. If it is to have a trial, let it be a fair one; but let it be made on the route that will involve the least outlay of the State's funds.

LETTERS TO THE EDITOR.

Subdividing Land Below a Meandered Boundary.

Sir: Your correspondent, "B. H. S.," in last week's issue of Engineering News, might be interested to learn that in Clute v. Fisher 65 Mich. 48, in his own state, it was held under circumstances similar to those he mentions: that the lines of the section subdivisions should be extended into the reclaimed area of the lake. This seems to have been followed in 137 Ind. 114, and 45 Mo. App. 335. But in Lamprey v. State, 52 Minn. 181, the court disagreed with this rule and held that the lines should be extended to the center of the lake. In Noyes v. Collins, 92 Iowa 566, it was held that the abutter had no rights at all beyond the original bank.

The best rule would probably be, that where the front is on a navigable water, the fronts must be proportioned to their original lengths (28 Mich. 182), but that where the water is "nonnavigable," the side lines are to be extended upon lines at right angles with the thread of the stream (19 Mich. 325). Yours truly, W. E. Kern,

3325 North Park Ave., Philadelphia, Pa., Sept. 8, 1902.

Effect of Back Water from Dams on Meadow Lands.

Sir: I desire to secure information on the effect upon streams and adjacent flat lands or low grounds produced by dams of long standing—say 75 or 100 years. The question involved is the damage done to agricultural flat lands from two to four miles above the dam, on a stream falling nearly uniformly 5 ft. per mile, the dam being 10 ft. high, measured from the water's surface at its down-stream side. The section through which the stream flows is easily eroded and gullied by heavy rainfalls, and the stream carries a large quantity of sand and silt. The flat lands from two to four, and even six, miles above the dam are for some cause becoming so swampy and marshy that they are almost worthless as agricultural lands, and suits are being brought against the owner of the dam, on the ground that the structure is the prime cause of this depreciation. I desire to get some authority on this subject, showing the effect of such dams in a large number of cases.

Respectfully, S. P. D.

Drake's Branch, Va. Sept. 2, 1902.

(The information desired is not available, so far as we are aware, except as a part of the experience of engineers and lawyers who may have been connected with similar litigation. Court records and decisions would doubtless throw some light on the case, and also the legal text-books on water rights, mill privileges and the like. We shall be glad to hear from any readers who may have had experience in such cases.—Ed.)

The Hydraulic Air Compressor at Norwich, Conn.

Sir: It is to be regretted that Mr. Knight, in his article on "The Hydraulic Air Compressor at Norwich, Conn." (Eng. News, June 12, 1902), should have given so little account of the details of the essential feature of the apparatus, viz.: the compressor. For example:

(1) No dimensions of the air or separating tank are given.

(2) The position of the safety pipe is not shown; there is no indication as to how much the lower end of this pipe is above the lower end of the downflow pipe; nor is its diameter given. To be told that these last are "such as to prevent the water being forced below the bottom of the downflow pipe" does not convey any clear idea for lack of other data.

(3) What is the head-piece? Fig. 4 of the article does not tell. Is it a part of the downflow pipe? Apparently not, because we are told that it "is situated vertically over the top of the downflow." If not a part of the downflow pipe, how far is it vertically above the latter? And how is it connected therewith?

(4) "The head-piece consists of a large number of tubes." . . . How many are there, and what is their diameter?

(5) "Means are provided for operating the head-piece for securing the proper immersion of the tubes and for regulating the amount of water passing through the head-piece." While it is not difficult to imagine means by which to do all this, it would be none the less interesting to know the means adopted in this special case.

(6) How is the outflow arranged after the water has passed out under the sides of the compression chamber? Is the outflow near the bottom or at some point further up not shown in Fig. 4?

(7) What pressure is obtained in the air main at the compressor, and what at the point of distribution? In other words, what is the loss of head in the four miles of main? F. A. Mahan.

51 Avenue Montaigne, Paris, France, Aug. 2, 1902.

(We give space to the above letter, because it illustrates very well the information which contributions to such a professional journal as Engineering News ought to contain, and in the second place, it illustrates the difficulties under which editors and contributors often labor in securing such information.

The reason why more detailed information concerning the apparatus was not given in the article as published was that the company preferred to have no further details concerning it made public. —Ed.)

Methods of Work in Government Land Surveys.

Sir: Commenting upon Mr. Hodgman's criticism of my method of subdividing a section (Eng. News, Sept 4, p. 170), I think he will find himself mistaken in saying that the method criticised is not in harmony with the statute. The act of Feb. 11, 1805, is contained in Sec. 2066, U. S. Rev. Stat., p. 439, and is there divided into several subsections. The first article directs that all corners not marked shall be found by running a line between the nearest corners on the same line and proportioning the distance. The second article provides for running lines between opposite quarter corners and fixing their intersection as the true center. A little study will show this and the first method to be susceptible of possible disagreement. The third section states that fractions of section shall be taken to be "as containing the ½ of ¼ part, respectively, of the returned contents of the section," &c. This is the clause upon which I base the method of subdivision criticised, and which method is therefore in harmony with both the statute and common law.

But without this, former Secretary Teller, in his letter of instructions to state and county surveyors, March 13, 1883, at pp. 12 and 13, states that after the land has been patented, "the United States having no longer any authority to order any changes when the lands affected by such corner have been disposed of," the matter must be left to the state courts, which, of course, enforce the common law.

Mr. Hodgman misunderstood the paragraph in my article referring to standards of measurements. This related more particularly to the survey of city lots and not at all to government surveys.

In my own work as a U. S. Deputy Surveyor, I never used a gunter chain, nor did I ever see any other deputy use one. We used the 100-ft. engineer's chain and reduced measurements to chains and links. All mineral survey notes are recorded in feet, and in my experience links were abandoned as soon as the township plats were filed in the surveyor-general's office. Yours truly,

W. E. Kern,

3325 North Park Ave., Philadelphia, Pa., Sept. 8, 1902.

The Box Column; Experience With Phoenix Columns.

Sir: Noting your editorial on "The Box Column" in Engineering News of Aug. 28, I would say that you seem to have somewhat overrated the superiority of box columns for steel-cage construction. Many other forms have been used by different designers with equally satisfactory results. The shape selected depends a great deal upon the circumstances the designer is placed in. He may be interested in introducing a patented combination of his own, like the Gray column, or he may be strongly influenced by the convenience of having all the elements of the column worked out, as the Z-bar columns are worked out in the Carnegie Steel Co.'s pocketbook. As long as only moderate sections are required, there are no special difficulties with any combination. The difficulties in building up large sections increase about proportionately to the area with any shape selected.. The box column has one great advantage in that it places the material in a more effective position in reference to the neutral axis than most others. The Phoenix column utilizes its material even better, but is not largely used in high building work on account of the supposed difficulty of making good connections without the use of cast iron.

As for the point you seem to be most in doubt about, that of inaccessibility of the interior of closed columns, the writer would call your attention to the experience that has been gained with Phoenix columns. They were largely used as early as the seventies in bridges, some of which are still standing and giving good service. A large number have been taken down by railways (in some instances re-erected for highway use), but in no case to the writer's knowledge has the interior of these columns been found in bad shape. It would be interesting to hear from any engineer whose personal experience with Phoenix-column bridges would either confirm or modify this statement.

Another case is that of a number of these columns used in the old blast furnaces of the Phoenix Iron Co. at Phoenixville, Pa., in positions where they were exposed to severe extremes of temperature and moisture. When the furnaces were dismantled, the columns were carefully examined and their interior was found in very good condition. If closed columns have come through the trying ordeal of railway and furnace use with such satisfactory showing, there seems to be no need of great alarm over their lasting qualities in building work.

Yours very truly, Henry Szlapka.

Narberth, Pa., Sept. 6, 1902.

Why Sewage Is Not Made a Source of Revenue.

Sir: In your issue of June 5, 1902, you suggested editorially that it might be well for a city newspaper to have either an engineer on its staff, or a consulting engineer to whom certain editorials should be submitted before publication. The suitability of such a course, at least in the case of the Boston "Transcript," was well illustrated by its editorial on the fall of the Campanile at Venice, quoted and commented on in your issue of July 25 last.

The "Transcript's" "engineering editor" is painfully appalled by the large sums of money *wasted* in "disposal" of our sewage instead of making it a source of revenue, as you will see by the enclosed clipping from the editorial page of yesterday's issue.

It seems too bad that high-grade papers like the "Transcript" should perpetrate such stuff.

Very truly yours, Engineer.

Boston, Aug. 26, 1902.

(The note enclosed reads as follows:

It is reported that the city of Tampico, Mex., has completed arrangements for the construction of sewer and water-works systems, and has appropriated $5,000,000 for general street improvements, the contracts for both systems being let to a New York contractor. The sum appropriated for the sewer system is not given, but it must be large. It is marvellous, in view of the rapid growth in scientific research and the inventiveness of our people, that we should still go on spending vast sums of money in disposing of our sewage instead of making it a source of revenue. Experiments in infiltration have been made in America as well as on the other side of the Atlantic, notably in France, but it does not appear that we are any nearer to practical results than we were when the experiments were in their early stages. The problem is a difficult one, especially because of the extent of territory that an infiltration bed for a large city or for even a large town would require; but it is hard to think that it never will be solved. Surely, we cannot forever go on spending so much money to throw away what should bring us in a greater amount of money to utilize.

The ideas expressed voice not only the popular view of the subject, so far as there is one, but they also coincide with occasional utterances from men of high scientific attainment. As a class, civil and sanitary engineers, alone, fully appreciate the obstacles to producing even a partial offset to the expense of sanitary means of sewage disposal. It is no wonder, therefore, that the best of our daily newspapers, unless they employ writers or critics versed in technical matters, should convey wrong ideas on the possible or probable revenues to be obtained from the disposal of sewage or any other city waste.

A careful analysis of the problem, however, would show most men having the quick perception possessed by the editors of American daily papers that the failure to make sewage disposal a source of income instead of outgo is not so "marvellous" as the "Transcript" editor declares. Modern ideas of convenience and sanitation, alike, demand that the composite wastes known as sewage shall be removed from houses as speedily and completely as possible, and water is the most effective agent to that end; in fact, the bulk of the wastes are dirty water in the first instance. Consequently, municipal sewage contains only some 2 parts per 1,000 of solid matter. Half of this solid matter is inorganic, while the organic matter constituting the other half is not immediately available as plant food. The heavy bonded indebtedness, fixed charges and operating expenses, to say nothing of the land area and host of municipal employees required to recover and make into available plant food this 1 part in 1,000 of organic matter in a city's sewage discharge, have appalled and are likely to continue to appal American municipalities, while a survey of foreign municipal conditions shows that the same general statement applies the world over.—Ed.)

Universal Irrigation.

Sir: Within the last year or two there appeared in the News an article—editorial, I think—urging upon engineers the duty of enlarging the bounds of their professional work by the discovery and promotion of new fields for the application of their powers to the conditions and needs of modern society.

The writer takes the liberty of proposing to the News and its readers the expediency and practicability of a wide and general application of irrigation to the agriculture of the country at large, without regard to the distinction generally made between the arid and sub-arid sections, on the one hand, and the sub-humid and humid on the other. In a word, universal irrigation is a subject that I commend to the consideration of the News and its readers.

The writer is well aware of the risk he incurs in making such a suggestion of having it criticised and condemned, possibly even ridiculed, as visionary, impracticable and absurd. He can only assure those whom he addresses that the suggestion is not made lightly or offhand, but

is the result of study and observation extending through several years. The next 20 years may see something done towards it. The next 50 years will probably see a good deal done. The next 100 years will see it an established fact.

Without general irrigation, agriculture in most parts of the East is and must continue to be carried on in only a semi-barbarous way, in which the seed is cast into the ground and left to the chances and vicissitudes of the seasons. This, more than anything else, is the real secret of the relative backwardness of agriculture in the East, its poor returns compared with other fields of labor; and the outcome of all this is the abandonment of the country for the town.

It is now high time that the American engineer—the man of trained and cultivated habits of thinking and acting in regard to material things—should come to the aid of the American farmer. What he has done in the field of transportation, in manufactures, in the iron and steel industry, in the cotton mill and factory, he must now try to do for the farmer.

It has been amply shown by actual experiments that irrigation under the conditions generally obtaining in the middle and eastern sections of the country is needed; that it has been and can be successfully practiced both with small and large means; that its results are highly satisfactory, and that properly conducted it pays handsomely.

The writer only regrets that his own time and means are so limited as to prevent him from doing what he now earnestly urges others more fortunately situated to do—make a full exhibition to the public of what has been done already in this direction, and base on this a demonstration of what can be done hereafter.

Chas. H. Scott, C. E.

Warrenton, N. C., Aug. 30, 1902.

(There is no doubt regarding either the ability or the willingness of the American engineer to meet any of the demands which may be made upon him to develop irrigation in any part of the country, or the world, just as effectually and notably as he has done his part in transportation and manufacturing, and if there were doubt, it would vanish on taking the most casual survey of the work of the irrigation engineer in the Western United States, Australia, India and Italy. It is not the engineer, but the land-owners and capitalists, who must take the initiative in the introduction, or rather the extension of irrigation, in the East and South. As to making public what has already been accomplished along these lines, the Irrigation Investigations Department of the U. S. Department of Agriculture, with an able engineering staff at its head, has already made a beginning, as may be seen from its reports and bulletins. But after all this has been said, doubtless there is a legitimate work for engineers in disseminating knowledge of the possibilities of irrigation for intensive culture in certain portions of the so-called humid regions of America. Anyone who has ever lived, or traveled much, in the staid old agricultural regions of the East knows full well that universal irrigation there is far more remote than aerial navigation.—Ed.)

FINAL REPORT OF THE NEW ENGLAND WATER-WORKS ASSOCIATION COMMITTEE ON STANDARD SPECIFICATIONS FOR CAST-IRON PIPE.

In our issue of Dec. 5, 1901, we printed a preliminary report on the above subject, and two weeks later we gave an abstract of the discussion which took place before the association on Dec. 11. Since the latter date the report has been further discussed, both orally and in writing, as may be seen by referring to recent numbers of the "Journal of the New England Water-Works Association." The report has also been submitted to the various pipe manufacturers, a committee representing which submitted a report and modified specifications dated Jan. 31, 1902, and requested a conference with the original committee. The foundry committee report, and the final report of the original committee, with amended specifications were submitted to the annual convention of the New England Water-Works Association, held this week in Boston. The full report, with discussion, will appear in a future number of the "Journal," and an abstract of the discussion will be given in our next issue.

We submit herewith a brief abstract of the report proper, and reprint in full the specifications, which have been changed in numerous minor and some major particulars from the preliminary draft given in our issue of Dec. 5, 1901.*

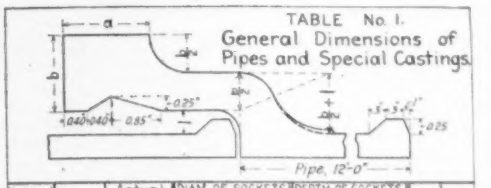


TABLE No. 1.
General Dimensions of Pipes and Special Castings.

Nominal Diam. Inches	Classes	Actual Outside Diam. Inches	Diam. of Sockets: Pipe Inches	Diam. of Sockets: Special Castings Inches	Depth of Sockets: Pipe Inches	Depth of Sockets: Special Castings Inches	"a"	"b"
4	A,C,E	4.80	5.60	5.70	3.00	4.00	1.50	1.30
"	G,I,K	5.00	5.80	"	"	"	"	"
6	A,C,E	6.90	7.77	7.80	"	"	"	1.40
"	G,I	7.10	7.90	"	"	"	"	"
8	A,C,E	9.05	9.85	10.00	3.50	"	"	1.50
"	G,I	9.30	10.10	"	"	"	"	"
10	A,B,C,D	11.10	11.90	12.10	"	4.50	"	"
"	E,F,G,H	11.40	12.20	"	"	"	"	"
12	A,B,C,D	13.20	14.00	14.20	"	"	"	1.60
"	E,F,G,H	13.50	14.30	"	"	"	"	"
14	A,B,C,D	15.30	16.10	16.35	"	"	"	1.70
"	E,F,G,H	15.65	16.45	"	"	"	"	"
16	A,B,C,D	17.40	18.40	18.60	4.00	5.00	1.75	1.80
"	E,F,G,H	17.80	18.80	"	"	"	"	"
18	A,B	19.25	20.25	20.40	"	"	"	1.90
"	C,D	19.50	20.50	"	"	"	"	"
"	E,F	19.70	20.70	20.70	"	"	"	"
20	A,B	21.30	22.30	22.50	"	"	"	2.00
"	C,D	21.60	22.60	"	"	"	"	"
"	E,F	21.90	22.90	23.00	"	"	"	"
24	A,B	25.40	26.40	26.60	"	"	2.00	2.10
"	C,D	25.80	26.80	"	"	"	"	"
"	E,F	26.10	27.10	27.10	"	"	"	"
30	A,B	31.60	32.60	32.60	4.50	"	"	2.30
"	C,D	32.00	33.00	33.00	"	"	"	"
"	E,F	32.40	33.40	33.40	"	"	"	"
36	A,B	37.80	38.80	38.80	"	"	"	2.50
"	C,D	38.30	39.30	39.30	"	"	"	"
"	E,F	38.70	39.70	39.70	"	"	"	"
42	A,B	44.00	45.00	45.00	5.00	"	"	2.80
"	C,D	44.50	45.50	45.50	"	"	"	"
"	E,F	45.10	46.10	46.10	"	"	"	"
48	A,B	50.20	51.20	51.20	"	"	"	3.00
"	C,D	50.80	51.80	51.80	"	"	"	"
"	E,F	51.40	52.40	52.40	"	"	"	"
54	A,B	56.40	57.40	57.40	5.50	5.50	2.25	3.20
"	C,D	57.10	58.10	58.10	"	"	"	"
"	E,F	57.80	58.80	58.80	"	"	"	3.80
60	A,B	62.60	63.60	63.60	"	"	"	3.40
"	C,D	63.40	64.40	64.40	"	"	"	"
"	E,F	64.20	65.20	65.20	"	"	"	4.00

In its final report the committee states that it had two conferences of two sessions each with a sub-committee representing the pipe foundries, including Messrs. Walter Wood, L. R. Lemoine, A. H. McNeal, and Overholt Long. While each side "naturally looked at the subject from its own point of view," yet the committee believes that

the net result was an endeavor to eliminate such requirements as would result in excessive cost of manufacture without a corresponding increase in quality of the pipe or facility in its use, and to retain all requirements tending to secure actual benefits to the users of pipe.

The committee agreed, wholly or in part, to some of the changes desired by the manufacturers, but did come to an "entire agreement" on all points. The chief point at issue was the one which was "most favorably commented upon" by members of the water-works association; namely, a uniform outside diameter for all pipes of the same nominal size. The committee thought that this plan would make such material savings in the patterns for the outsides of the pipe as to render the change acceptable to the manufacturers, but it found that any such saving was more than offset by

the vastly increased number of fittings which would be required for the casting of the inside of the socket of the pipe where the inside diameter varies with each class. There was, besides, a danger that the pipes would be of poor quality if too great difference in the thickness of the pipe were made by increasing the thickness of the clay core.

The final outcome of the deliberations was in modification of the "design of the pipe" so as "to retain the advantages of a single class of castings for all of the classes of the smaller size of pipe, and the possibility of using the pipe interchangeably." How this has been effected may be seen by referring to the revised tables, reproduced herewith.

The specifications submitted required so much time that the committee was obliged to defer the presentation of tables showing the design and standard weights for special castings; but in general design the specials recommended are like those used on the Metropolitan Water-Works.

The specifications submitted to the association for adoption were as follows:

PROPOSED NEW ENGLAND WATER-WORKS ASSOCIATION STANDARD SPECIFICATIONS FOR CAST-IRON PIPE.

Sec. 1. DESCRIPTION OF PIPES.—The pipes shall be made with hub and spigot joints, and shall accurately conform to the dimensions given in Tables Nos. 1 and 2. They shall be straight, and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter. They shall be at least 12 ft. in length, exclusive of socket. For pipes of each size from 4 to 16 ins. in diameter there shall be two standards, and for each larger size three standards of outside diameter. The inside diameter of each class shall be increased from the nominal size in the manner hereinafter specified, so as to obtain the standard thickness and weight. For pipes from 4 to 16 ins. in diameter one class of special castings shall be furnished with all classes of pipes. For pipes from 18 to 24 ins. in diameter, Class D special castings shall be furnished with pipes of Classes A, B, C, and D, and Class F special castings with pipes of Classes E and F. For pipes 30 ins. in diameter and larger, Class B special castings shall be used with pipes of Classes A and B, Class D special castings with pipes of Classes C and D, and Class F special castings with pipes of Classes E and F.

All pipes having the same outside diameter shall have the same inside diameter at both ends. The inside diameter of the lighter pipes of each standard outside diameter shall be gradually increased for a distance of 6 ins. from each end of the pipe, so as to obtain the required standard thickness and weight for each size and class of pipe.

Sec. 2. ALLOWABLE VARIATION IN DIAMETER OF PIPES AND SOCKETS.—Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gages, and no pipe will be received which is defective in joint-room from any cause. The diameters of the sockets and the outside diameters of the spigot ends of the pipes shall not vary from the standard dimensions by more than .06-in. for pipes 16 ins. or less in diameter; .08-in. for 18-in., 20-in. and 24-in. pipes; .10-in. for 30-in., 36-in. and 42-in. pipes; and .12-in. for 48-in., 54-in. and 60-in. pipes.

Sec. 3. VARIATION IN THICKNESS.—For pipes whose standard thickness is less than 1 in., the thickness of metal in the body of the pipe shall not be more than .08-in. less than the standard thickness, and for pipes whose standard thickness is 1 in. or more, the variation shall not exceed .10-in., except that for spaces not exceeding 8 ins. in length in any direction, variations from the standard thickness of .02-in. in excess of the allowances above given shall be permitted.

Sec. 4. DEFECTIVE SPIGOTS MAY BE CUT.—Defective spigot ends on pipes 12 ins. or more in diameter may be cut off in a lathe, and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than 12% of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than 11 ft. in length, exclusive of the socket.

*The committee is composed of Mr. Freeman C. Coffin, M. Am. Soc. C. E., Consulting Engineer, 53 State St., Boston; Mr. F. F. Forbes, Superintendent of Water-Works, Brookline, Mass.; and Mr. Dexter Brackett, M. Am. Soc. C. E., Engineer Distribution Department, Metropolitan Water-Works, 1 Ashburton Place, Boston.

TABLE No. 2.
Standard Thicknesses and Weights of Cast Iron Pipes
12 feet in length exclusive of socket.

Nominal Diam. of Pipe	Class A. Thickness of Shell	Class A. Weight per Length	Class B. Thickness of Shell	Class B. Weight per Length	Class C. Thickness of Shell	Class C. Weight per Length	Class D. Thickness of Shell	Class D. Weight per Length	Class E. Thickness of Shell	Class E. Weight per Length	Class F. Thickness of Shell	Class F. Weight per Length	Class G. Thickness of Shell	Class G. Weight per Length	Class H. Thickness of Shell	Class H. Weight per Length	Class I. Thickness of Shell	Class I. Weight per Length	Class K. Thickness of Shell	Class K. Weight per Length
	Inches	Pounds	Inches	Pounds	Inches	Pounds	Inches	Pounds	Inches	Pounds	Inches	Pounds	Inches	Pounds	Inches	Pounds	Inches	Pounds	Inches	Pounds
4	.34	200			.36	215			.39	230			.42	245			.45	260	.48	275
6	.38	330			.42	355			.46	385			.50	415			.54	440		
8	.42	475			.48	525			.53	575			.58	630			.63	685		
10	.47	650	.50	685	.53	725	.56	765	.60	805	.63	845	.67	885	.70	925				
12	.49	810	.53	865	.57	920	.61	980	.65	1035	.69	1090	.73	1150	.77	1210				
14	.53	1010	.57	1085	.61	1155	.66	1230	.70	1300	.75	1380	.79	1458	.83	1530				
16	.55	1215	.60	1310	.65	1410	.70	1500	.75	1600	.80	1700	.85	1800	.90	1900				
18	.57	1410	.63	1540	.69	1660	.75	1790	.80	1910	.86	2040								
20	.60	1610	.66	1760	.72	1920	.79	2080	.85	2250	.92	2410								
24	.64	2050	.72	2290	.80	2530	.88	2770	.95	3000	1.03	3240								
30	.71	2860	.81	3230	.91	3600	1.01	3950	1.10	4320	1.20	4680								
36	.79	3800	.90	4270	1.02	4830	1.13	5300	1.25	5900	1.37	6360								
42	.87	4900	1.00	5560	1.13	6270	1.27	6970	1.40	7700	1.53	8350								
48	.95	6130	1.10	6970	1.25	7900	1.40	8780	1.55	9740	1.70	10600								
54	1.03	7510	1.20	8600	1.37	9800	1.54	10900	1.72	12350	1.90	13500								
60	1.10	8900	1.30	10300	1.50	11900	1.70	13300	1.90	15100	2.10	16500								

In case the length of a pipe differs from 12 ft. the standard weight of the pipe given in Table No. 2 shall be modified in accordance therewith.

Sec. 5. SPECIAL CASTINGS.—All special castings shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications.

The diameters of the sockets and the external diameters of the spigot ends of the special castings shall not vary from the standard dimensions by more than .08-in. for castings 16 ins. or less in diameter; .10-in. for 18-in., 20-in., and 24-in. pipes; .13-in. for 30-in., 36-in., and 42-in. pipes; and .16-in. for 48-in., 54-in., and 60-in. pipes.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The contractor shall furnish and deliver all bolts for bolting on the manhole covers, the bolts to be of the sizes shown on plans, and made of the best quality of mild steel, with hexagonal heads and nuts and sound, well-fitting threads.

Sec. 6. MARKING.—Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe and special casting shall also have cast upon it figures showing the year in which it was cast and the number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below; thus,

1901	1901	1901
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall be not less than 2 ins. in length and ⅛-in. in relief for pipes 8 ins. in diameter and larger. For smaller sizes of pipes the letters may be 1 in. in length. The weight and the class letter shall be conspicuously painted in white on the inside of each pipe and special casting after the coating has become hard.

Sec. 7. PERCENTAGE TO BE PAID FOR.—No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5% for pipes 16 ins. or less in diameter, and 4% for pipes more than 16 ins. in diameter; and no excess above the standard weight of more than the given percentages for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received the sum of the standard weights of the same number of pieces of the given size and class by more than 2%.

No special casting shall be accepted the weight of which shall be less than the standard weight by more than 10% for pipes 12 ins. or less in diameter and 8% for larger sizes; and no excess above the standard weight of more than the above percentages for the several sizes will be paid for.

Sec. 8. QUALITY OF IRON.—All pipes and special castings shall be made of cast iron of good quality, and of such character as shall make the metal of the castings strong, tough, and of even grain, and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

Sec. 9. TESTS OF MATERIAL.—Specimen bars of the metal used, each being 26 ins. long by 2 ins. wide and 1 in. thick, shall be made without charge as often as the engineer may direct, and in default of definite instructions the contractor shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 ins. apart and loaded in the center, shall for pipes 12 ins. or less in diameter support a load of 1,900 lbs., and show a deflection of not less than .30-in. before breaking, and for pipes of sizes larger than 12 ins., shall support a load of 2,000 lbs. and show a deflection of not less than .32-in. The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars. Should the dimensions of the bars differ from those above given, a proper allowance therefor shall be made in the results of the tests.

Sec. 10. CASTING OF PIPES.—The straight pipe shall be cast in dry sand molds in a vertical position. Pipes 16 ins. or less in diameter shall be cast with the hub end up or down, as specified in the proposal. Pipes 18 ins. or more in diameter shall be cast with the hub end down.

The pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Sec. 11. QUALITY OF CASTINGS.—The pipes and special castings shall be smooth, free from scales, lumps blisters, sand holes, and defects of every nature which, in the opinion of the engineer, unfit them for the use for which they are intended. No plugging or filling will be allowed.

Sec. 12. CLEANING AND INSPECTION.—All pipes and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped.

Sec. 13. COATING.—Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle, nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300° F. immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300° F. (or less, if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated, the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

Sec. 14. HYDROSTATIC TEST.—When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressures to which the different sizes and classes of pipes shall be subjected are as follows:

	Pounds per sq. in. for diameters of—	
	20 ins. and larger	Less than 20 ins.
Class A	150	300
Class B	200	300
Class C	250	300
Class D	300	300
Class E	350	350
Class F	350	350

Sec. 15. WEIGHING.—The pipes and special castings shall be weighed for payment under the supervision of the engineer, after the application of the coal-tar pitch varnish. If desired by the engineer, the pipes and special castings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Bids shall be submitted and a final settlement made upon the basis of a ton of 2,000 lbs.

Sec. 16. CONTRACTOR TO FURNISH MEN AND MATERIALS.—The contractor shall provide all tools, testing machines, materials, and men necessary for the required testing, inspection, and weighing at the foundry of the pipes and special castings; and, should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the transverse tests upon the test bars.

Sec. 17. POWER OF THE ENGINEER TO INSPECT.—The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding, casting, and coating of the pipes and special castings. The forms, sizes, uniformity, and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which is not in conformity with the specifications or drawings furnished.

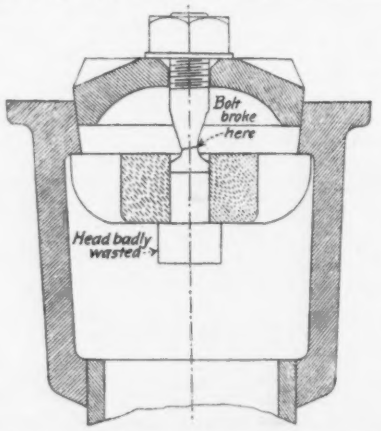
Sec. 18. INSPECTOR TO REPORT.—The inspector at the foundry shall report daily to the foundry office all pipes and special castings rejected, with the causes for rejection.

Sec. 19. CASTINGS TO BE DELIVERED SOUND AND PERFECT.—All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other casting which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract, provided, however, that the contractor shall not be held liable for pipes or special castings found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation or at any time after they receive the coating.

Sec. 20. DEFINITION OF THE WORD "ENGINEER."—Wherever the word "engineer" is used herein, it shall be understood to refer to the engineer or inspector acting for the purchaser, and to his properly authorized agents, limited by the particular duties intrusted to them.

EXPLOSION OF AN ECONOMIZER.*

An explosion occurred from a Green economizer at Stalybridge some time ago and resulted in the death of two men. It is desirable that our readers should be in possession of the principal facts of the case, because there are important lessons to be learnt from them. The economizer was made in 1888 by E. Green & Sons, Ltd., and it was, by arrangement with the owners, inspected four times a year by them, three times in work and once



Top End and Cover of Economizer Tube.

"thoroughly." The economizer consists of 384 vertical cast-iron tubes, 4 9-16 ins. diameter externally, the upper ends of which are expanded into cast-iron boxes and closed by covers secured by one bolt. The "thorough" inspection consisted in dividing the pipes roughly into groups of 100 each and removing two caps from each group and examining the tubes inside. The last time this was done was in August, 1901, and the inspector found the economizer generally in good condition. On Feb. 10 of the present year some of the caps leaked, and two men went with a wrench and a piece of piping 3 ft. long to attend to them. Soon afterwards the bodies of the men were found near the door of the economizer room, and the cap of one of the tubes was found on the floor. The drawing of the cap, which appears below, tells everything else that is needed. The bolt was wasted where shown to ⅝-in. diameter, and broke under the strain of ening up.

The obvious lessons to be learnt from this unfor accident are: (1) That the inspection is inadequate. do not go as far as the commissioners, from whos port we take the facts, who are of opinion that eve should be removed once a year, we have no doubt ever that more than 2% should be inspected. Th that many other bolts were subsequently found d confirms us in this view. (2) The danger of inte with bolts under pressure is again impressed upo The practice is always inadvisable, and it is absol dangerous when a joint which has been good, pos for months, gives out without visible cause. W moreover, the joint is metal to metal, as in the pr case, it is bordering on madness. The fact that the is blowing is an indication that the bolt is not doing work. Mark it, therefore, and examine it when t pressure is off. (3) If you are going to do a danger thing, make sure your way of retreat. If these unf tunate men had left the door open, they might possib have escaped. They reached it, but were apparently overcome by that time to open it.

*Reprinted from "The Engineer" (London).

BOOK REVIEWS.

SELF-HELP MECHANICAL DRAWING, An Educational Treatise.—By N. Hawkins, M. E., Author of Hand Book of Calculations, etc. New York: Theo Audel & Co. Cloth; 10 × 6¾ ins.; pp. 299; illustrated. $2.

With the purpose of aiding the "aspiring" student in making a first advance towards a thorough knowledge of drawing, the author commences with blackboard sketching and then passes to freehand drawing and to the use of instruments and a knowledge of the principles of geometrical and mechanical drawing, linear perspective, projection, etc. With the persistence in the student—that Mr. Hawkins properly says is essential to success—much can be learned from this treatise.

HIGH TEMPERATURE MEASUREMENTS.—By H. Le Chatelier and O. Boudouard. Translated by Geo. K. Burgess, Instructor in Physics, University of Michigan. New York: John Wiley & Sons. Cloth; 12mo.; pp. 230; 52 illustrations. $3.

The development within the past few years of a variety of instruments and methods for accurately measuring high temperatures has made possible such a book as the one before us. Its chief author is a well-known French physicist, who has won distinction by his invention of one of the most widely known pyrometers; and the book ought to completely cover the limited field with which it deals. So far as European practice is concerned, it does this very well, but the extent to which the authors ignore what has been done on this side of the water may be indicated by the fact that the well-known and widely used pneumatic pyrometer of Uehling and Steinbart* is nowhere even mentioned. This omission would deserve serious criticism in the edition published abroad; but it is much more flagrant in the case of an edition translated by an American and issued by an American publisher.

Our impression of the work as a whole is that it is written by a physicist from a physicist's standpoint, and in that field it is a monograph of much value, bringing together in one place information only to be found by extended search through the transactions of numerous scientific societies. As a practical manual, for the use of those using pyrometers in industrial operations, it will prove disappointing, we fear; and will find purchasers and users only by reason of the fact that there is nothing else to fill its place.

WATER-TUBE BOILERS.—Based on a Short Course of Lectures at University College, London. By Leslie S. Robertson, M. Inst. C. E. New York: D Van Nostrand Co. Cloth; 8vo.; pp. 213; 171 illustrations. $3.

The scope of this book is stated in its first chapter as follows: (1) A historical description of the better known types of water-tube boilers from the early attempts to the present day; (2) the consideration of the general principles underlying the construction of steam boilers, but dealing with them only in so far as they immediately concern water-tube boilers; (3) a discussion of the principles underlying the circulation of the water and the hot gases; (4) a short description of the better known types of water-tube boilers; (5) boiler mountings and accessories; (6) weight and space occupied; (7) advantages and disadvantages of this type of boiler.

The historical and descriptive part of the book is very complete and thoroughly good. The index shows that no less than 134 different makes of water-tube boilers are mentioned in the text, and most of them are illustrated by cuts of more than usual clearness. A large majority of these boilers were failures. They are of interest not only as matters of history, but as warnings to future inventors of boilers. It is to be regretted that the author has not clearly pointed out the causes why these boilers failed and made clear the essential points of difference between a bad and a good form of water-tube boiler. In a pamphlet published several years ago by a leading manufacturer of water-tube boilers the principal cause of failure of boilers of this type was shown by an illustra-

*Fully described in Engineering News of Nov. 14, 1895.

tion of a gravestone among a scrap heap of such boilers, with the inscription, "They could not be cleaned."

Under the head of "Combustion," the author states the "points to be borne in mind" in the design and management of furnaces for water-tube boilers as follows:

(1) The grate area should be as large as possible.
(2) The volume of the furnace over the bars should be as great as possible, so as to ensure the proper mixing of the gases before entering the tubes.
(3) Sufficient air must be introduced below and above the grate to ensure complete combustion.
(4) Gases must not enter the nests of tubes before combustion is complete.
(5) Gases should be forced to remain as long as possible in contact with the tubes.

These "points" are good, but the 1st, 3d and 5th are rendered indefinite by the words "as possible," and they furnish no proper answer to the question, How large should be the grate area, the volume of the combustion chamber and the length of travel of the gases for a boiler under which, say, 1,000 lbs. of smoky coal per hour is to be burned? The third point is defective in not showing that no amount of air will ensure combustion of the gases if it is not made very hot. The fourth point is strictly correct, but the author should have pointed out that it is persistently violated in every water-tube boiler in which the attempt is made to burn soft coal directly under the boiler. No mention is made in the book of firebrick furnaces built in front of the boiler, which are beginning to be used in this country.

Accessories to water-tube boilers, such as reducing valves, steam separators, feed-water regulators, filters, etc., are described and illustrated in the concluding chapter, and brief statements are made as to the weight and space occupied by water-tube boilers and as to their advantages and disadvantages. An appendix contains the "Interim Report" of a committee of the British Admiralty on modern boilers for naval purposes.

SOME EARLY SUBMARINE TORPEDO BOATS.*

By G. W. Baird,† Commander U. S. N.

Among some unpublished manuscripts in my possession I have many of the notes of the late Engineer-in-Chief W. W. W. Wood, of the Navy, as well as my own notes, sketches, etc., on the subject of torpedo boats, of both the surface and submarine classes.

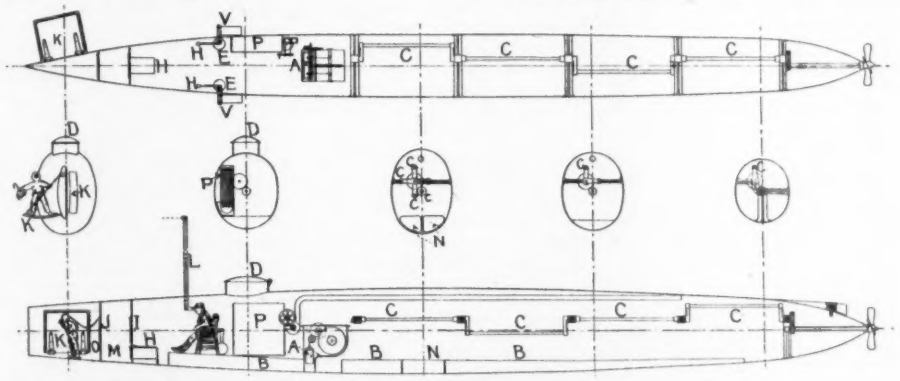


FIG. 2. HORSFORD'S SUBMARINE TORPEDO-BOAT, 1864.

When a Third Assistant on board the "Pensacola" during the Civil War, I had the pleasure of assisting Second Assistant Engineer Alfred Colin in the measurements and drawings of a submarine torpedo boat which had been fished out of the canal near the "New Basin," between New Orleans and the Lake Pontchartrain. Mr. Colin's drawing was sent by the Fleet Engineer (Mr. Shock) to the Navy Department.

The boat was built of iron cut from old boilers, and was designed and built by Mr. McClintock, in his machine shop in the City of New Orleans. She was 30 ft. in length, the middle body was cylindrical, 10 ft. long, and the ends were conical. She had a little conning tower with a manhole in the top, and small, circular, glass windows in its sides. She was propelled by a screw, which was operated by one man. She had vanes, the functions of which were those of the pectoral fins of a fish. The torpedo, like that of Bushnell, was of the clock-work type, and, also like that of Bushnell, was intended to be screwed to the bottom of the enemy's ship. It was greatly superior to Bushnell's in that it was carried on top of the boat, and the screws employed were gimlet-pointed and tempered steel. Mr. McClintock (whom I met after the Civil War had ended) informed me that he made several descents in his boat, in the lake, and succeeded in destroying a small schooner and several rafts. He stated that the U. S. SS. "New London" and "Calhoun," had been a menace on the lake, and this gave rise to the torpedo boat; but before an attack was made the fleet of Farragut had captured New Orleans, and his boat was sunk to prevent her falling into the hands of the enemy. His boat required but two men to operate it. He said they might have remained several hours under water without being seriously inconvenienced and without any extra storage of air. His ballast keel, which could be detached from the inside, was so weighted as to barely let the boat float with the conning tower awash. He frankly stated that the model of the boat was improper, in that the small displacement afforded by the sharp ends was insufficient to keep the boat on an even keel if a man moved a few inches forward or aft, and that this was a serious objection. After the capture of New Orleans, Mr. McClintock went to Mobile, where he built the boat shown in Fig. 1. The boat was carried by rail to Charleston and was successfully employed in the destruction of the U. S. steam sloop

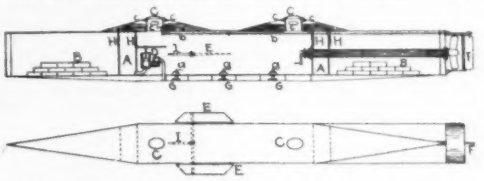


Fig. 1. McClintock's Submarine Torpedo-Boat, Mobile, 1862.

A.—Water compartment.
B.—Pig-iron ballast.
C.—Manhole.
D.—Pump.
E.—Vanes.
F.—Rudder.
G.—Detachable weights.
H.—Manholes.
I.—Handles for vanes.
a.—Handle for detaching weights.
b.—Steering rod.
c.—Windows.

"Housatonic." The torpedo boat, it will be seen, has a cylindrical middle body, but wedged-shaped ends. From the figures given me by Mr. McClintock, I made, in his presence, sketches, from which I made the above drawing. The clock-work torpedo was abandoned with the New Orleans boat. The boat shown in the engraving used "a torpedo on a pole," as Mr. McClintock expressed it. The torpedo boat was not, apparently, injured by the explosion, but, for want of power, failed to regain the harbor, and, by a fresh wind, was blown out to sea and lost. The boat was steered, as shown, by a rod which passed through a stuffing-box in the stern. She had the "pectoral" vanes, and the detachable ballast of her predecessor, beside a bilge pump and water-tight compartments. It was found that it was not necessary to secure the ballast carried inside the boat. He found, in practice, that he got better results by placing the "pectoral" vanes near the center of displacement; that his purpose was as well, and easier served, by sinking or rising bodily on an even keel as by diving. The utmost speed he could get with eight men was but three knots an hour; that the vitiated atmosphere rapidly diminished the men's strength; they complained more of being tired than from headache or nausea. That the boat was easily managed under water, and, when submerged 10 ft., she was not sensibly affected by the surface waves.

So far as the hydraulics of submarine-boat construction and the management of submarine flight are concerned, the experiments of McClintock in 1862-3 seem to have been conclusive. He had never heard of the boats nor the efforts of Bushnell nor of Robert Fulton. His inventions were as real as theirs, and, though not actually original, they were honest inventions. He belonged to that class of men who, in war and in peace, will ever be leaned upon in emergencies. The cause which led to Bushnell's inventions also led to his.

In 1863 our government purchased from a Frenchman a torpedo boat which resembled Robert Fulton's "Nautilus." It was essentially a navigable diving bell—a cigar-shaped vessel 6 ft. diameter at the middle, and about 50 ft. in length, propelled by "duck-foot" paddles worked through holes in the sides (ball and socket joints). She was built of iron. Like the "Nautilus," she had a hole in her bottom amidship. She had air-tight compartments, in which air at great pressure was stored. The boat could not descend to great depths without injury to the crew. The hole in the bottom afforded an opening for the crew as well as the torpedo. In smooth water it is by no means a difficult feat for a good diver to enter or leave through such an opening. The government paid $10,000 for the vessel, and substituted a screw propeller for the paddles, by which a marked increase of speed was obtained. An attempt to tow the boat to a Southern port was then made, but she was lost off Hatteras. The contact of the air inside the boat with the water afforded a simple means of purifying the air, and though not entirely sufficient for that purpose, contributed much to it.

In 1864 Professor Horsford designed a large submarine boat which possessed good features. Fig. 2 shows longitudinal section and plan, which need but little description. The Professor estimated that his vessel could remain submerged for "several days" at a time. She was propelled by man-power, through cranks and a screw propeller. The pectoral vanes were held in horizonetal plane by pendulums, to insure horizontal flight. He employed water ballast for increasing or diminishing the weight of the vessel, using a pump to handle the water. He used, also, cast iron internal ballast. Tubes having each two mirrors, as shown, which reached above the water, enabled the navigator to see above the surface. These tubes were intended to be telescopic, that they might be extended or shortened. By means of the pair of tubes and their angle when focused, the Professor expected to determine distances. At A his anchor and windlass are shown. At H is the hydraulic port, and the diver about to place the torpedo. That which merits the most consideration is his method of purifying the air. A tank of oxygen gas, compressed to one-fifteenth its volume, was used. He employed a great surface of woolen cloth (P), which passed over pulleys and was dipped in lime water. A blower (P, Figs. 1, 2 and 4) kept the air moving over the wet surface. The lime water absorbs the carbonic acid gas. As this gas is absorbed and a small amount of oxygen liberated, the air may be kept nearly at normal purity. A common soda font (containing 45 cu. ins. of oxygen at atmospheric pressure) will supply one man 81 hours.

Submarine exploration has been practiced in all civilized parts of the world. In 1858 Van Buren Ryerson invented and put in practical use a greatly improved bell, which merits a place in this essay. Fig. 3 is a longitudinal section of the bell. A is an air-tight chamber in which air is compressed; D is a door, on a rubber joint; I is a diaphragm for separating the chambers A and G. A small opening at g communicates chambers G and H. A stop cock at B admits air from the chamber A to the chamber S. A stop cock at C communicates chambers A and H. The bottom chamber G is of cast iron, is the heaviest part of the bell and is for ballast. When the water is exhausted from G the dome of the bell will float above the surface of the water. When the bell is in use the workmen, standing on the bottom, move the bell by pressure of their hands. When the air becomes foul a few strokes of the pump (P) will project a jet of water into the bell, which readily absorbs the carbonic acid gas. From this absorption there will be a little rise of water in the bell, which, in turn, is depressed by admitting compressed air from the chamber A, as described. When it is desired to rise to the surface, water is expelled from the chamber F by pressure of air, which may be let in from the chamber A, and thus the bell becomes manageable, in smooth water, by the men inside.

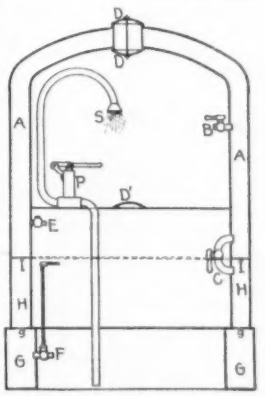


Fig. 3. Ryerson's Diving Bell, 1858.

Upon one occasion, when the air had been so far breathed by the men that it would no longer support the combustion of a candle, a sample of the air was taken, and by subsequent analysis, 100 parts of it contained:

Oxygen	16.0 parts.
Carbonic acid	8.0 "
Nitrogen and vapor	76.0 "
Total	100.0 parts.

After the spray pump had been worked about 10 minutes the air contained:

Oxygen	26.0 parts.
Carbonic acid	1.5 "
Nitrogen and aqueous vapor	72.5 "
Total	100.0 parts.

Thus it appears, from actual test, that the revived air contained 10% more oxygen than the impure air and about 5% more than the normal atmosphere. It must be remembered that the air absorbed by the water is a little richer in oxygen than the normal atmosphere, and also that the quantity of air held in water increased with the depth (vide "Journal Franklin Institute," January, 1872). In the experiment above recorded, the bell was operating in 20 ft. of water. The weight of 100 cu. ins. of air in the bell previous to the operation of the spray pump was

*Reprinted from the "Journal of the American Society of Naval Engineers," for August.
†Member American Society of Naval Engineers.

33,000 grains; after the operation of the spray pump it was 31,025 grains. In the former case there were traces of ammonia, sulphur and chlorine, and the air was so impregnated with carbonic acid gas as to render lime water rapidly turbid. In the latter case there were more evidences of chlorine than in the former, but neither sulphur nor ammonia were apparent, nor did the lime water appear turbid. From this it may be seen that the sea water may be utilized greatly to our advantage.

Following the lines of Ryerson, and taking up the boat of Kroehl, we connect the diving bell with the dirigible submarine automobile.

Julius H. Kroehl, Chief Engineer of the Pacific Pearl Co., invented and put in use a navigable submarine explorer, which is shown in Fig. 4. Its invention was a necessity. The pearl divers would not work under water without knives to defend themselves against the "devil fish" (the cephaloptera-vampyrus), but when so armed

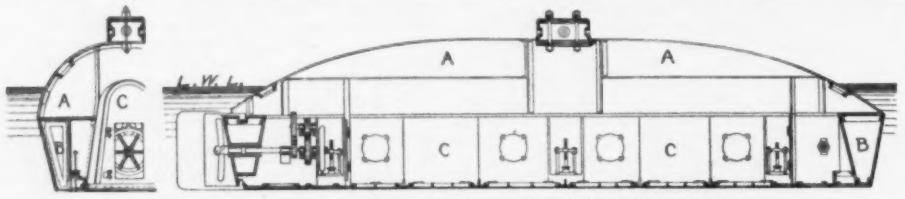


FIG. 4. KROEHL'S SUBMARINE EXPLORER, 1864.

they would open the pearl oysters under water, abstract the pearls and so cheat their employers. Kroehl's vessel is but an improvement on Ryerson's bell, having a propeller as means of moving in free water away from the bottom. It was built in New York in 1864, and carried to the Pearl Islands, near the Bay of Panama, where it was successfully used and, Mr. Kroehl said, the divers employed in the boat enjoyed better health than the other divers.

The vessel had three principal divisions: (1) The compressed-air chambers (A); (2) the ballast or water chambers (B); (3) the working chambers (C). Excepting in its propulsion it was operated much the same as Ryerson's bell. The bottom of the boat could be opened or closed, as desired. When exploring in considerable depths the bottom was closed, to save the crew from the heavy pressure.

Mr. Kroehl, in 1861, designed a "cigar-shaped boat," but abandoned it for a flat-bottomed boat, as shown. His boat was 36 ft. long and 8 ft. beam. At the center, between the compressed-air chambers, there was a distance of 7 ft. 11½ ins. The screw was 3 ft. 6 ins. diameter, and was worked by hand. Mr. Kroehl was of opinion that his boat could have been used for war purposes, in entering harbors and severing electric wires which led to planted torpedoes. This would not be a very difficult thing to do, nor would it incur as great danger as might be supposed. Under water, in day time, it is easy to see anything above, but not easy to see below you. At night, with an incandescent lamp under a boat, one could see the bottom if very close, but the lamp screened by the hull, could not be seen from the surface in 20 ft. of water.

About 20 years ago the writer insulated a 16-c. p. electric lamp and lowered it into the clear water of the Gulf Stream when the surface was smooth. At a depth of 50 ft. the last glimmer had disappeared. On the Bahama banks, in 25 ft. of water, the white bottom could be barely seen when a lamp was lowered to it, but when a reflector was placed above the lamp, the bottom was plainly visible.

All efforts to get speed out of a submarine boat have been futile; nor is it essential, for if the vessel becomes invisible there will be no need of haste. The application of an electric motor to the propulsion of a torpedo boat, by Scott Sims, about 20 years ago, made it possible to drive such a boat about 8 or 9 miles an hour, but the power required would soon exhaust any storage batteries.

However, enough has been already determined to assign the surface and the submerged boat each to its place in naval warfare. The surface boat, crammed with machinery, much of which is above the water line, with the water in its boilers so heated as to make every pound of it exceed, in potential, the explosive force of an equal weight of gunpowder, must face the deadly fire of the rapid-fire guns. To give the surface torpedo boats an opportunity for success, they must in day time hunt in droves, and their commanders may feel satisfied if 1 in 20 strikes a successful blow. At night they may go single, but slowly.

The submarine boat is not quite out of the experimental state. A number of practical points, those not recorded in text-books nor taught in school, must be ascertained by experiment. The more modern submarine boats are, in some respects, improvements on those referred to in this paper, yet such improvement is but in the details. The problem is tentative and purely mechanical, and needs now but practical tests to develop it. The writer became interested in the subject at an early age, and has always been of the opinion that the danger incurred in a surface boat is greater than in a submerged boat.

It may, however, be found, in actual practice, that the capabilities of both surface and submerged boats have been overestimated, but that both, doubtless, will be found to have their places in warfare. As a submarine explorer, Kroehl's boat was a success. There is no difficulty in submarine wireless telegraphy, as every boy knows who has had his head under water when another boy was beating stones together; the impression upon the tympanum of the ear is acute and painful during such an operation. It only remains to improvise a code of signals in order to utilize this system and establish communication between a fleet and the bottom of a blockaded harbor.

It has long been known that the explosion of a torpedo upon the bottom will kill fishes in that vicinity, indeed, this is now practiced by Canadian fishermen. It becomes at once of interest to know what would be the result of an explosion near a submarine boat, and the best methods and best form of boat to resist such a contingency. There are other practical questions which need to be determined, but it is needless to multiply them here. Such a boat as McClintock or Kroehl produced, propelled by an electric motor and storage battery, would answer for all experimental purposes, and not be very expensive. A generating set in the boat would add greatly to its complication, and, in the opinion of the writer, would rather detract from than add to her efficiency.

THE OPERATION OF CENTRIFUGAL MINE PUMPS AT HORCAJO, SPAIN.

In our issue of Jan. 23, 1902, we described and illustrated an interesting installation of turbine-type pumps for high lifts at the silver mines of Horcajo, Province Ciudad Real, Spain. The pumps are used for draining the mine, and lift the water in four stages, each pump (except the lowest) having a head of about 470 ft. to overcome. The pumps are driven by direct-connected three-phase induction motors with short-circuit winding; these motors have a capacity of about 250 HP. each at a speed of 850 to 900 r. p. m., and take current under a pressure of 1,000 volts. Up to the time our article appeared the pumps, and, in fact, the whole installation had proven very satisfactory, but no figures were available as to their operation. Quite recently our contemporary, "Engineering," of London, England, described the Horcajo pumping plant in its columns. Thereupon the engineer of the mining company, Mr. Paul H. Ziegler, sent a communication to that journal in which he gave some figures as to the operation of the pumping plant. We reprint portions of his letter below, as the installation in question is rather novel and yet thoroughly modern, and that type of pumping plant for mine drainage and many similar purposes seems likely to come into more extended use.

Since Oct. 6, 1901, we have been raising the water from the 20th level (at 1,365 ft.) by means of four pumps. The three upper pumps, mounted on the 8th, 15th and 19th levels, are each provided with four wheels, while the bottom pump contains only two wheels. The four pumps are all identical except that in the last-mentioned instance one or several wheels are removed, the space being filled by a fixed piece, so that the lifting power of the pump is reduced in proportion to the number of wheels, and that a pump can be utilized to the desired extent by adding the respective number of wheels.

The maximum quantity of water so far brought up in a day of 24 hours was 261,000 cu. ft., or 181.3 cu. ft. per minute. Making allowance for stoppages, the total deliveries and the average amounts delivered per minute have been as follows during the past two and a half years:

Period	Total pumpage, cu. ft.	Average, cu. ft. per min.
1900	63,760,000	132.3
1901	69,425,500	131.3
1902 (January to June)	37,018,500	140.1

During the first months of this year, 1902, the centrifugal pumps have had to work under excessively unfavorable conditions. There had been in the mines a caving in of some quartz-bearing clay which rendered the water very muddy. The pumps worked perfectly in spite of this during the whole period the muddy water had to be dealt with; this period lasted fully six weeks, and the pumps showed no sign of particular wear.

The stoppages of the pump service are by no means frequent, and are distinctly decreasing. The total stoppages were:

Period.	Time stopped, hrs.	mins.
1900	525	10
1901	258	..
1902 (January to June)	95	10

The cause of the stoppage was almost always [illegible] cleaning the wire cage over the suction pipe at the bottom of the shaft.

Mr. Ziegler further refers to the coal and steam consumption of the pumping plant, to its efficiency, and to the cost of pumping. A poor quality of coal is used, developing 6,500 calories and costing 40 pesetas (= $5.90) per long ton. This fuel evaporates 7.3 lbs. of water per lb. of coal, according to tests.

The average consumption of coal per effective horse-power hour, and the steam consumption (the work in both cases being measured by the water raised), are as follows:

Period.	Coal used, lbs. per eff. HP. hr.	Steam used, lbs. per eff. HP. hr.
1900	5.83	42.6
1901	5.34	39.0
1902 (January to June)	5.61	40.9

This consumption is obviously very great when we compare it with that of pumping engines of modern type. It should be borne in mind, however, that we work under special conditions at Horcajo as regards our steam engines. The engines had not been constructed for the speeds at which they have to run, and the steam consumption cannot but be high. Notwithstanding this circumstance, the actual cost of pumping derived from the quantity of water delivered is not so high as one might believe:

Period.	Costs in cents of raising 100 cu. ft.
1900	7.99
1901	7.85
1902 (January to June)	8.36

These figures include all the materials, coal, oil, etc., as well as labor and repairs; they do not include amortisation of the machinery capital.

We have made experiments as to the efficiency of the centrifugal pumps. When the installation included only three pumps, taking water from the 19th level at a depth of 1,276 ft., the maximum efficiency of the pumps alone was 75.94%, the pumpage then being 134,100 cu. ft. of water per 24 hours. With this performance, the efficiency at the switchboard was 68.29%.

A word deserves to be added here with regard to the low percentages of interruptions of service. Mr. Ziegler cites these percentages as testimony in favor of the pumps, and they are without doubt worth noting in this regard. They speak equally well, however, for the satisfactory and reliable performance of the electric equipment, especially the motors, which do their work below ground in damp chambers, and have probably much less careful attention than similar machinery mounted in a station building above ground.

A PROPOSED NEW BROOKLYN BRIDGE TROLLEY TERMINAL PLAN.

A plan for a new trolley car terminal at the Manhattan end of the Brooklyn Bridge has been submitted to Mayor Low by the Manufacturers' Association of New York city. The arrangement of tracks for the new terminal is shown in the accompanying cut, which also shows the present terminal arrangement for purposes of comparison. The new plan is the design of Mr. Nells Poulson, President of the Hecla Iron Works, who explains its arrangement and method of operation as follows:

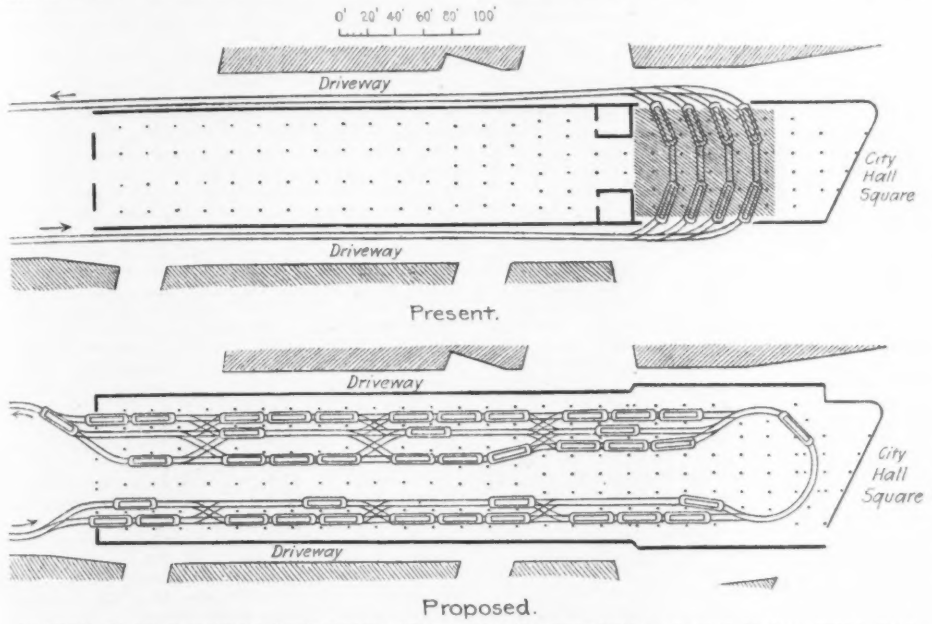
The drawings show the number of square feet the Manhattan terminal building occupies, the number of square feet used for car service, and the number of square feet for standing room between the cars, likewise the unused space. The proposed plan includes the one-story sidings, taking up the space occupied by the tracks of the present trolley lines from the eastern end of the building to the western end next to Park Row, giving over 56,000 sq. ft., which are all used for car service, and over 30,000 sq. ft. left for platform. The loop being elevated, no tracks will have to be crossed and no moving cars dodged. By this plan the cars would enter the terminal, coming from Brooklyn, at the eastern end, discharge all the New York passengers on the outside, and when empty switch over to a parallel track on the inside, then make the loop and go to their respective stations on the outside or inside track on the opposite side, take loads of passengers, switch over to the center trunk line and then proceed to Brooklyn. The plan submitted is drawn to show the columns as they are in the building. It can be seen easily that at present the congestion is all at one point, and that by the proposed plan use can be made of the large amount of space in the building which is now apparently waste ground, and by relieving the congestion at one point and distributing the crowd the crush at the bridge will be relieved.

It was necessary to have the switching of bridge trains at the Park Row end of the building when they instituted the cable system, but now that the electric system is substituted, the switching can be done at the other end

Under the proposed plan there can be four trains of six cars each in the station at one time standing still for loading. This alteration can be made quickly and at no great expense, and it will make it more easy for the trolley system below, as there will be no galleries in the way. At the Park Row end of the building there will be a platform of about 100 × 115 ft., and from that platform there can be as many stairways as are wanted, but, instead of stairways, it would be better to have an inclined promenade from the elevated floor to the City Hall Park.

As here proposed, there are three distinct plans—one for the trolley service, one for the bridge trains and one for the promenade. Each alteration can be introduced separately, but all three can be combined. Undoubtedly the best plan would be to combine all three. The whole scheme can be put into practical use in a few months, before the cold weather sets in, and before the crush begins when the closed cars are used.

The new plan has received the commendation of President Greatsinger of the Brooklyn Heights R. R., whose cars use the bridge tracks, and is also favorably criticised by Mr. Gustav Lindenthal, Commissioner of Bridges of New York city. As the result of the conference with Mayor Low it was decided to submit the plan to a committee of experts, one to be suggested by the Bridge Commissioner, one by the Brooklyn Rapid Transit Co., and one by the Manufacturers' Association, all of whom, after the names are suggested, will be appointed by the Mayor.



SKETCH PLAN SHOWING PROPOSED NEW TROLLEY TERMINAL AT THE MANHATTAN END OF THE BROOKLYN BRIDGE COMPARED WITH THE PRESENT TERMINAL ARRANGEMENT.

ENGINEER'S REPORT ON THE GARBAGE FURNACES OF TRENTON, N. J.

The first thorough-going engineering investigation of the operations of an American garbage furnace of which we have knowledge was recently completed at Trenton, N. J., by Mr. Rudolph Hering, M. Am. Soc. C. E., of Hering & Fuller, New York city. Mr. Hering's report, which has just been made public, will, we trust, be the beginning of better things in garbage disposal in America, the unsatisfactory condition of which has often been pointed out in these columns. The report was dated Aug. 18, 1902, and was addressed to Mr. Wm. S. D'Arcy, Chairman of the special committee of city councils "appointed to investigate the workings of the city crematory, against which numerous complaints have been made." The report is so comprehensive a study of both the local conditions at Trenton and of garbage cremation in general that we reprint it entire, with the exception of the formal opening paragraph.

The special committee submitted the report to the city council on Sept. 2, with the recommendation that the "police committee carry out the line of improvements suggested in the report." The committee stated that it was appointed "to investigate the causes of fire in the vicinity of the crematory," and that after several public hearings it employed Mr. Hering. In a minority report a single member of the committee states that in his opinion the fires were caused by the crematory; that the crematory is not fulfilling the contract guarantee; and that no large outlays for improvements should be made until "recourse has been had upon the guaranty" of the contractor. The report follows:

On Aug. 1, I visited Trenton with our principal assistant, Mr. Theodore Horton, met your committee, was informed of the conditions, and subsequently examined the furnace which, I was informed, had been running since Aug. 1, 1901, just one year from the date of this visit. Mr. Horton remained several days to make more extended observations and to collect the required data.

DESCRIPTION OF CHIEF PARTS OF CREMATORY.

The works are located on the west side of Southard St., near the Delaware and Raritan Canal. The base of the furnace is placed one story below the street level, so that the garbage can be readily delivered from the street to the floor level above the furnaces, and easily be fed to them through openings in the floor, or feed holes. The furnaces and feeding floor are enclosed in a brick building, apparently well and strongly built.

The crematory is of the Davis type, and consists of two complete garbage furnaces connected by separate flues to a single chimney stack.

The chimney is built of brick, has an internal section of 5 ft. sq., and is about 120 ft. high above the base and about 100 ft. above the entrance of the flues. In the stack are a set of screens of ½-in. mesh, for the purpose of intercepting dust and larger particles escaping from the fires, and also a regulating damper which can be operated from a point near the feed holes.

Each furnace consists of: (1) An arched drying chamber, 8 ft. sq. and 8½ ft. high to the key of the arch, into which the garbage is dumped through a feed hole. It is provided with grates, chiefly for drainage purposes. The garbage remains in this chamber during the process of draining and drying, and at intervals it is raked down with long iron rakes into the combustion chamber.

(2) An arched combustion chamber, 4 ft. long, 6 ft. wide and 4 ft. high to key, placed in front and approximately at the same level of the drying chamber. It is provided with grates on which coal is burned to assist the burning of the garbage which the attendant rakes down from the drying chamber.

(3) A main flue, about 3 ft. wide by 3½ ft. high, leading from the furnace to the chimney stack.

(4) An arched secondary flue, 4½ ft. long by 5½ ft. wide and 3 ft. high, in which is situated a set of fire grates about 2 ft. long and 4 ft. wide, and on which auxiliary fires are kept burning, ostensibly for the purpose of completely eliminating odorous fumes on their way to the stack.

(5) A so-called evaporating pan, under and of the same area as the drying grate, into which the liquid from the garbage freely drains. Some of this liquid may be evaporated, but most of it is led off by a 4-in. drain pipe to the sewer in the street.

(6) A feed hole or opening above the drying chamber, through which the garbage is dumped. It is closed with a movable iron cover.

(7) Grate bars, about 4 ft. long and 4 ins. wide, the openings between which are ⅛-in. wide for the fire grates and ¼-in. wide for the drying grate.

(8) Ash pits under all grates, and firing and observation gates or doors complete the chief parts of the installation.

The chimney stack, the furnaces themselves and their parts appear to be built of good material and indicate good workmanship. The station appeared to be kept clean and in good order.

THE CITY'S REFUSE.

The city's refuse may be classified as follows: (1) Ashes, bottles, cans, and other non-combustible material, which is collected and disposed of by tipping and filling at various places in the city.

(2) The garbage proper or house refuse, being largely of combustible nature and known also as "swill" or "slop," containing at the present season much fruit, and being almost saturated with water, is collected and delivered at the crematory by the city in special garbage carts.

(3) Garbage and refuse from stores, markets, etc., is collected and brought to the crematory by private parties. Much of it is of a very combustible nature, such as paper, rags, straw, wooden boxes, etc.

The collection and disposal of the first of these classes, apparently not causing any trouble, has not been considered in this investigation. The disposal of the garbage and refuse mentioned as the second and third classes has been a cause, however, for serious complaint, and to this the investigation is limited.

Speaking generally, the sources of the troubles complained of may be stated as follows, and are subsequently discussed under separate headings:

(1) Collection of garbage, and odors arising from it when delivered at the works.

(2) Odors from the ashes after their removal from the furnace, when retaining some incompletely burned material.

(3) Dust of completely burned garbage escaping from the stack and depositing in the neighborhood.

(4) Unburned or still burning particles of garbage escaping from the stack and depositing in the neighborhood, with the possibility of falling upon shingle roofs or inflammable material and thereby causing fires.

(5) Odors due to the unburned gases escaping from the stack.

COLLECTION OF GARBAGE AND ODORS ARISING WHEN DELIVERED AT WORKS.

The city garbage is collected in iron carts of approved make, holding about one ton and drawn by two horses. The carts collect from all parts of the city, daily except Sunday, and between the hours of 8 a. m. and 6 p. m. Each one serves a certain district, the number of trips being of such frequency that each house is visited as many as two or three times each week, according to the season. The carts are watertight, sanitary in every way, and so far as we know have not given any offense.

The private garbage and dry refuse is brought to the crematory in the ordinary store wagons. We were not made aware that such collections had given any offense.

The dry refuse, such as paper, wood, rags, etc., is generally collected from the houses in large bulk, while the garbage proper is first put into pails, boxes or barrels, usually left open, and subsequently collected by the teams.

On arriving at the crematory the contents of the carts and wagons are immediately dumped into the furnaces, unless these are already charged to their full capacity, in which case the wagon is detained or left standing until one of the furnaces is in a condition to receive the charge.

The only odors which may arise from the present method of city collection, can be caused by the often improper and usually open receptable, but chiefly by the occasional filling of the carts beyond their normal capacity, so that the lids do not close, and odors may be given off while the carts pass along the street. The same objection may apply also to the private wagons for collecting garbage, but so far as we know, complaints have not been made.

These sources of trouble are easily prevented by proper municipal regulations and due care. Among the other essentials to prevent offensive odors from arising before the material is subjected to the burning process, are frequent collections of the garbage in proper vehicles, both of which you have already provided for very satisfactorily.

ODORS FROM ASHES AFTER REMOVAL FROM FURNACE WHEN RETAINING SOME INCOMPLETELY BURNED MATERIAL.

Offensive odors arise when the ashes are removed from the grates and deposited in exposed places before the garbage is thoroughly burned. This trouble is especially likely to occur with a crematory like yours, located in the midst of a thickly settled district where such odors are more readily noticed than in remote districts.

On the day of our first visit to your crematory there was a strong odor emanating from the pile of clinkers or ashes which had been dumped in front of the building. An examination showed that it was due to quite a number of unburned pieces of animal and vegetable refuse.

This annoyance clearly cannot occur if the garbage is so thoroughly consumed upon the grates that nothing but clinkers and ashes remain when their removal from the furnace is necessary. The remedy for the defect is therefore clear:

(1) The furnace must be in a condition to be capable of completely burning the organic matter, of which more will be said below. (2) The attendant must be very observant

and attentive in not pulling out anything but thoroughly burned material.

This inattention has at other places been a frequent cause of objectionable results and therefore of complaints. Too generally it is supposed that any stoker or fireman quite familiar with handling coal fires is also able to handle garbage fires. The latter, due to the presence and mixture of the greatest variety of combustible and non-combustible matter, are very much more difficult to operate than simple coal fires. When starting the furnaces in Hamburg, the most extensive garbage plant in the world, and also the experimental furnaces in Berlin, it was found necessary to import firemen from England, where crematories have been in use for 50 years, in order to train the German firemen in the special art of garbage cremation. It is an art that requires experience, skill and a faculty for constant attentive observation, which can be acquired only under skilful guidance by continued practice of intelligent and faithful men.

DUST OF BURNED GARBAGE ESCAPING FROM STACK AND DEPOSITING IN NEIGHBORHOOD.

When garbage is carefully burned and the combustion is complete, there may yet be trouble from the fine ashes of paper, wood, rags, and other organic matter escaping from the stack and being carried with the wind to greater or less distances, even entering windows and causing dirt and consequent annoyance.

This nuisance is chiefly due either to faulty design of the flues or chimney, or in improper manipulation of the draft, or to both. In fact, ashes should not be carried up into the stack at all, but be deposited in enlarged flues or dust chambers on the way to the stack. These chambers should be given a relatively large sectional area, in order that the velocity of the fumes may be retarded and the heavier dust particles settle out, thus leaving practically the gases alone to pass freely out through the stack.

Even if the flues and dust chambers are properly designed, improperly designed dampers or their careless manipulation may also be the cause of this trouble. Dampers should have the full size of the flues, and be provided with simple mechanism so as to be easily operated from the fire-room or from a point near the feed hole. They should be always closed when the feed hole is open for charging the furnace, and also whenever the furnace doors are open for the purpose of firing, stoking or cleaning. That is, they should be almost tightly closed, leaving only enough draft so that fumes do not rise into the building from the feed hole or furnace doors. In general, they should always be under such careful control and so manipulated that the velocity of the gases in the settling chamber and the flues can be maintained below a certain required maximum rate. What this maximum rate should be, permitting the dust particles to settle, we are not able to state with desirable definiteness, because the data are meager concerning such deposits, which depends upon the size of the particles and their specific gravity; the finer and lighter the particles, of course, the more readily they are kept afloat in the moving gases.

It may, however, be safe for practical purposes at present to estimate that the velocity of the current through the dust chamber should be kept as low as from 1 to 1.5 ft. per sec. In order to secure this reduced velocity, we must first know the volume of gas which passes through the dust chamber in a given time. It is a variable quantity and depends on the chimney draft and the manipulation of the dampers. With the proper grate area for the burning of 30 tons of garbage per day, we may, however, roughly estimate the volume of air required for the combustion as being about 150 cu. ft. per sec. This would therefore require a sectional area of at least 100 sq. ft., or more than four times the combined area of the present flues.

To facilitate further the deposition of dust it is an advantage to have the level of the inlet as far as possible below the level of the oulet, so that the force of gravity, slight as it would be, can favor rather than hinder the tendency for the dust to deposit.

The construction of a dust chamber of ample dimensions, placed beween the furnaces and the stack, and properly designed dampers, would very materially, and with careful manipulation in accordance with the momentary conditions of the openings at the feed hole and gates, probably wholly, remedy the defect discussed under this heading. The chamber should, however, be constructed with a sufficient number of baffles to secure a uniform reduction in the velocity, not allowing the gases to pass through more quickly in the center than along the sides.

UNBURNED PARTICLES OF GARBAGE ESCAPING FROM STACK.

The effects of completely burned particles of garbage escaping from the stack have just been described. The annoyance from the partly or wholly unburned particles now to be considered is more aggravated, owing to their charry or greasy nature, and, as they are heavier, also to their tendency to settle more quickly and therefore more densely in the immediate neighborhood of the crematory. There is, furthermore, the possibility of still burning or glowing particles setting fire to roofs or to inflammable material in the streets or yards.

To determine the extent of this nuisance, careful observations were made, and it was observed, almost without exception, that particles of black-charred paper and similarly light material escaping from the stack could be seen at intervals during a whole day. They were apparently more numerous shortly after the furnace doors or the feed holes were opened, which naturally caused an increased draft through the flues and chimney. The damper, which is supposed to be closed during the feeding of garbage to the furnace, was not always operated with the necessary ease during the days of our inspection.

To determine how far reaching this nuisance was in the neighboring districts, observations were made at distances of one-quarter, one-third and one-half a mile from the crematory, during one afternoon when the conditions appeared to be normal. The day was clear, and the wind was blowing at an estimated rate of about ten miles per hour. At a distance of one-quarter of a mile from the stack, about fifteen charred particles were observed in ten minutes to pass a plane at right angles to the direction of the moving smoke. At a distance of about one-third of a mile about ten particles passed in ten minutes, and at a distance of two-thirds of a mile two particles passed in ten minutes. The size of these particles varied from one-quarter of an inch to three-quarters of an inch square, averaging probably less than one-half an inch square.

Further observations were made by selecting places in fields, where the ground was sufficiently open to aid one in finding particles which might have previously settled on the ground. These places were selected always in the line of the moving smoke. The sizes of the particles were about the same as those first mentioned. At a distance of about two-thirds of a mile from the crematory, and after searching for about fifteen minutes, two charred particles were found on an area of 50 ft. sq. At a distance of one-third of a mile, after the same interval, eight particles were found on an area of about 15 ft. sq. For how long a period these particles had accumulated cannot be stated. As a heavy rain had fallen during the previous night, sufficient in all probability to destroy traces of particles previously deposited, and as the wind had been in the same quarter only during the afternoon, it seems probable that these particles were the accumulations of only a few hours.

Observations were also made regarding the escape of burning embers from the stack. They were best undertaken ht night, while the crematory was yet in full operation and when the burning particles were readily visible. On each of two nights, and extending over periods of from two to three hours, the burning particles from the stack were closely watched with the following results:

(1) No embers were seen in a flaming condition. (2) Glowing embers were generally emitted after the opening of the furnace doors for firing, cleaning or raking down of the garbage. (3) During these times it was estimated that an average of 50 to 100 sparks were emitted per minute. Of these it was further estimated that 50% did not travel in a glowing state more than 25 ft. from the top of the stack; 90% not over 50 ft.; 95% not over 75 ft.; 99% not over 100 ft., and rarely one could be seen 150 to 200 ft.

From these observations it is evident that the trouble from escaping particles of unconsumed garbage is a serious one, and worse than if merely burned dust escaped from the stack.

In seeking for means to remedy this defect, we must carefully inquire into its two prime causes, namely, the incomplete combustion in the furnace and too great a velocity of the fumes in the flues. It will, therefore, be necessary in your case to: (1) Secure more perfect combustion, as will be referred to below. (2) Construct between the present furnaces and chimney stack a dust-settling chamber, as already suggested above. (3) Insert separate dampers in the flues leading from each furnace, which will enable each furnace to be practically shut off when charging the grates, and will admit of regulating the draft at will whenever necessary. It may be added here that a careful observation and study will be required to know how to use all the dampers effectively. It is necessary to observe the effects of their position according to the temperature of the gases in the stack, the opening of one or both feed holes and of one or both firing or observation doors. After knowing these separate effects for different atmospheric conditions, explicit directions should be given, and conscientiously followed, for the manipulation of the dampers under all these conditions.

ODORS DUE TO UNBURNED GASES ESCAPING FROM STACK.

The stench resulting from incomplete combustion is usually the most serious trouble that arises from garbage cremation, and it is the one which in our country does not seem to have as yet been completely solved at any one of the principal garbage furnaces. It is in my opinion, in addition to what has already been said, largely due to the design of the furnace. A fruitful discussion of this subject must necessarily be divided into a careful examination of: (1) The character of the material delivered, its composition, moisture and combustible matter. (2) The essential parts of the furnace to obtain a complete combustion of such material. (3) The manipulation of charging, discharging, regulating drafts, etc. I shall [illegible] up each topic separately.

(1) THE MATERIAL DELIVERED.—The burning quality of garbage depends principally upon three things: The amount of combustible material which it contains; the amount of fine material or dust chiefly of an incombustible nature which fills the pores and obstructs the free access of air; and the amount of moisure. Garbage which is poor in combustible material will not readily burn under any conditions, and garbage though rich in combustible material may yet be so filled with moisture as not to burn without previous drying, or the interstices may be so completely filled with fine ashes or dirt that combustion is retarded and even prevented by the lack of air.

In European cities, where garbage and city rubbish is mixed also with ashes, the combined refuse is comparatively dry, and the percentage of unburned coal in the ashes, together with the combustible matter of the garbage itself, is sufficient in properly constructed furnaces to burn without the addition of fuel. In our country, however, there are many cities, as Trenton, where it has become the practice to separate the ashes and the garbage. The burning then may become a more difficult matter and ofttimes can only be accomplished by the addition of fuel.

Regarding the propriety of separating the refuse substantially into ashes, dry rubbish and kitchen garbage, much can be said on both sides. The wisdom of separating the ashes in Trenton from the rest of the refuse, under the present circumstances, should be considered only from the economical point of view. That is, would the amount of unburned coal remaining in the ashes after sifting make it unnecessary to purchase clean coal for assisting the fires in the furnace, and would the total expense of delivering the ashes at the crematory, of sifting them and of subsequently disposing of the siftings, be less than that of the present method? I am not prepared now to answer this question, as it would require an investigation much larger than was necessary for present purposes, and was not undertaken also for the reason that the installation of the furnaces is not sufficiently large to treat the great bulk of clinkers, slag and ashes that would thus be added to the fires and also require temporary storage.

To compare the garbage of Trenton with the same class of refuse in London, Berlin, New York and Boston, of which I have the information, Table I. is presented, showing the various percentages of material of which garbage is generally composed.

The table gives only a partial list of the materials which in some of these cities were quantitatively determined, and includes only the garbage proper for the purpose of comparing it with that of Trenton. The table shows that the garbage of Trenton is not very different from that of other cities, being as rich as any in combustible matter. The percentage of moisture, however, is very high, and though reliable data concerning this point are not available for all of the cities, I have reason to believe that it is higher than in any of the other cities given in the list. This, of course, is an important matter in any process of disposal by combustion.

Let us take, for instance, the 31 tons of garbage delivered in Trenton per day, with 80% moisture. (See Table II.) This quantity will therefore contain approximately 24 tons of water which must be eliminated in the furnaces either by drainage or evaporation before the garbage can be completely burned.

Assuming that all must be evaporated in the furnaces, and taking as a basis the usual value of 10 lbs. of water evaporated to 1 lb. of coal, it will require 2.4 tons of coal to evaporate this water. The 20% solid material in the garbage, about 90% of which is combustible, will daily yield roughly six tons of dry combustible material. With a conservative calorific value of one-third that of coal, this gives an equivalent of 2.0 tons of coal, thus leaving a net average amount of about 0.4 tons of coal which must be added daily to consume the garbage with its present quanity of moisture.

The amount of coal now actually consumed per day was found to be 2.3 tons. It is therefore clear that the arrangements of the furnace, or the manner in which it is operated, or both, are not economical. At certain seasons when the garbage is not so moist as now, it seems that less or even no coal, except to start the fires, may be needed other than on rare occasions.

Our observations show that much of the water which is brought with the garbage and settles to the bottom of the carts, percolates through the drying grate into the evaporating pan, which was quite filled with perhaps half a ton of water. To evaporate all these drippings would require a considerable amount of heat.

It is clearly more economical, from a calorific point of view, to prevent this large amount of water from getting into the furnace, than to let it first pass through what is supposed to be the drying chamber and then into sewer. It is quite proper, and it is the custom in many places, particularly in Europe, to dump the garbage on the floor around the feed holes, not only to mix the material properly for burning, as will be mentioned later, but to let what water will drain off go directly into the sewer. The economical as well as beneficial effect of this prior draining during at least a large part of the year will be quite noticeable.

It is of course not possible for me to indicate for the different months of the year what would be the actual moisture after draining. Nor could it even then be stated just how much coal, if any, would be required for each month. I am satisfied, however, that the calorific value of this garbage is such that its complete combustion could be secured with a much smaller amount of coal that is now used.

To obtain this result, it will be necessary to operate the crematory along the lines already mentioned with a view of preventing a nuisance, and to have a furnace in which the combustion of the garbage can be more economically obtained, i. e., to insure complete combustion without excessive loss of heat. It remains, therefore, to examine into the essential parts of

(2) THE GARBAGE FURNACE.—Although the nature and composition of garbage affects greatly the relative burning qualities in any furnace, the successful burning in any case will depend primarily upon the construction of the furnace itself.

Garbage furnaces in England, where they have been used for half a century, are usually divided into small units called cells, in a manner similarly to a battery of boilers, and are arranged in pairs straddling a common main flue. Each cell has a separate connection with this flue and is operated independently of the other cells. The grate area of one cell is usually 25 sq. ft., this being the size which has been found to be most conveniently and economically operated. The grate bars are usually detachable and have an effective air space of about 25% to 30% of the grate area. They are usually inclined to the front so that the garbage from the feeding hopper can slide down or be raked down upon them. The chamber over the grates is of ample size, longer than the grates, and slopes with the grate surface. Over the upper end of this incline is the hopper and opening for receiving the garbage. As it burns away on the grate below, the raw material above slowly slides down to take the place of the consumed material. While descending, it is subjected to the influence of the heat from the fire in front and gradually dried and then automatically ignited. The stoker observes the process and aids it by properly pulling and spreading fresh material at the rear and drawing out the hard clinkers and ashes in front.

The gases and hot air pass into flues usually above the grates, and then into a settling chamber where the dust particles deposit. Then they again enter the main flue and pass through the chimney. Generally the gases also pass through a so-called fume-cremator where they are reduced to an inodorous condition. In some European refuse destructors, as they are called, the heat of these gases from the main flue is utilized in making steam for power or electric lighting. To aid combustion, forced draft is frequently resorted to, either by steam jet or air jet, the jet entering under the grates of the furnace. It is found greatly to increase the burning. Dampers are placed on the main flues and on the flues connected with each cell. The latter are always closed during the process of firing, raking or cleaning of a cell. Ash pits and cleaning doors are provided under the gates of each cell, also cleaning doors at the settling chamber, flues and chimney.

American garbage furnaces differ essentially from the European in that the grate surfaces are much larger and practically horizontal. The result of this practice is that when wet garbage is dumped here and there upon the burning garbage, the fire is suddenly and partially extinguished below. A very irregular burning is caused thereby which it is necessary to improve by the addition of coal. It also requires more skilful stoking and spreading of the heterogeneous material over the large horizontal grate and a more difficult operation in removing the clinkers, than in a furnace with a sloping chute and a grate of much smaller area, on which the material is gradually brought from a moist state to one of great heat, resembling a self-feeding coal furnace.

The amount of garbage burned in each English cell will depend upon its composition and moisture. With proper drying it is usual in Europe to burn five to seven tons per day per cell of 25 sq. ft. of grate area. In the Berlin Experiment Station something less than six tons were burned, and owing to the small amount of combustible material in the Berlin garbage it was necessary to add some coal during certain seasons.

Considering the furnaces operated in your city, in the light of the above remarks, the nature of their defects seems to me apparent. The grates of both combustion and drying chambers are horizontal, so that the garbage stays where it drops, and can only be moved forward and spread with some difficulty by the aid of large heavy rakes. The garbage when dumped into the drying chamber is formed into a dense heavy pile, only the upper portion of which is usually raked down upon the combustion grates, leaving the lower portion undisturbed and unburned often until the last of the garbage is consumed at night. This raking down of the upper portion does not insure that the garbage will be completely burned. Even pulling it down upon the coal fire in front does not do this, unless much more time and skill are used than was observed during our examination.

The amount of garbage burned in Trenton per equivalent of English cell area (see Table II.), is as much as about 14 tons, considering only the coal-grate surface in the combustion chamber, while in Europe the quantity ranges from six to seven tons.

It must be realized, however, that in Trenton much burning takes place in the first or drying chamber. All of the highly combustible materials, as paper, wood, straw and the like, are there consumed and should not be credited to the second or combustion chamber. Although in Trenton, to aid combustion, about 120 lbs. of coal are used per ton of garbage, in Europe the unused coal in the ashes of the mixed garbage amounts, roughly speaking, to the same quantity.

The analysis in Table I. indicates that, leaving out the ashes with its unburned coal, the net burning quality of European and American garbage is not very different. This evidence, although it is meager, indicates that you cannot maintain a higher rate of combustion per square foot of grate area than is maintained in the furnaces abroad. Independently of the material burned over the grate of the drying chamber, which I think we might estimate as being at least one-fourth of the total amount, we still have a much greater amount of garbage proportionally per square foot of grate surface passing through the combustion chamber than is found to be practicable in the best furnaces abroad.

From this reasoning we may infer that the combustion in Trenton is not as thorough as in England, and such inference seems to agree with the facts as found.

Remedies for this defect of insufficient combustion in the furnace can be obtained: (1) By increasing the number of furnaces. (2) By running the crematory for 24 hours. (3) By improving the burning capacity of the furnace.

To increase the number of furnaces is a matter that will need attention in any event at no distant day. By building another furnace at once, the present overcharge could be relieved. Whether an additional furnace had best be built at the present site or in another part of the city, where it might decrease the length of haul for collection from some districts, while increasing the unit cost of labor for attendance, I did not ascertain.

Should it be found impracticable to build another furnace at present, it is entirely practicable to run the present crematory for 24 hours, in other words, continuously, by using two or probably three shifts.

Continuous operation has merits, in a more uniform service and in a saving of the losses of heat due to cooling and to the starting of fires every day. At present you are frequently obliged to run during a portion of the night, and the additional cost of running continuously would not be proportionately greater.

Continuous operation requires storage of the garbage for use during the hours when no collections are made. Should all garbage be collected in 12 hours and burned at a rate to consume it in 24 hours, storage must be provided for one-half a day's supply. This at present would be about 15 tons, requiring about 25 cu. yds. of storage. If piled 2 ft. high this requires a space less than 20 ft. sq., for which there is ample room.

Referring to what has been said regarding the preliminary draining of the garbage and what will yet be said regarding the feeding to the fires, this storage on the feeding floor is an advantage to be recommended to you also for day service, whenever the state of the fires and an unfavorable previous charge makes temporary storage of some of the garbage necessary in order to obtain better combustion. The temporary storage of this material for a few hours cannot cause any nuisance if it is freshly collected. Such storage is customary in Europe under similar conditions.

While the continuous operation of the furnaces can relieve some of the present difficulties, the third-mentioned remedy, namely, the improvement of certain parts of the furnaces, should be likewise recommended.

An improvement which I believe to be of much practical value in securing complete combustion without excessive loss of heat, is the introduction of the sloping grate, and of a drying chamber having a floor sloping towards this grate at a sufficient angle to feed, if not automatically, yet with only slight aid from the stoker. By this means the garbage passes gradually from its natural state to that of complete combustion, and the difficulties of stoking are reduced to a minimum. The hottest fire will be near the front of the furnace, and here the fumes get their most effective burning.

The gases should therefore leave the furnace near the front. They should pass to the rear outside, but closely to the walls of the drying chamber, and in such a manner that these are heated as much as practicable, and thus help the drying process from the bottom, sides and rear of the chamber, as direct radiation from the hottest fire helps it in front.

Should the garbage be well drained on the feeding floor, the drying chamber would need no grate nor evaporating pan.

Regarding the introduction of forced draft by blowers forcing air under the grates, it may be said that the advantage of this assistance is recognized in Europe and utilized in the best furnaces.

I have no hesitation in expressing the belief that an improvement in the design and operation of your furnaces, with a greater air pressure below the grate, could enable steam to be made in sufficient quantity to operate such blowers, but also, as may be inferred from what has been said above, accomplish the burning with much better effect as regards the escape of unburned particles than the aspiration from a more rapid chimney draft, drawing up the fumes from the upper surface of a mass of burning garbage.

Under the present heading it yet remains to speak of the auxiliary fires burning between the furnace and the chimney. Without question such fires are needed at times when for one reason or another it is advisable separately to cremate the fumes coming from the furnace before they ascend the chimney. In your case this may always be required, because the location of the crematory is near the built-up parts of the city, and because the difficulty in training men to operate such a plant properly always points to the wisdom of having a safeguard against slight imperfections of manipulation. Such auxiliary fires, must, however, also be carefully run to secure the object for which they are kept burning, and at any time proof of this should be readily obtainable by inspection.

(3) THE OPERATION OF THE FURNACE.—Almost, if not equally as important as the proper design of a furnace, is its skilful operation, and too little attention has usually been given in our country to this feature of garbage destruction. A little indifference or carelessness even with the best furnace can result in incomplete combustion, with the resulting annoyances above described. It is a simple matter to burn a homogeneous material, such as coal or wood, but to operate a furnace with probably the most complex mass of matter apt to be found in a modern community, is difficult and also serious from the deleterious effects resulting from failures. The employment of specially trained firemen having good judgment, attentive and faithful, seems to determine the success or failure of the undertaking.

Good judgment with regard to the conditions and time of firing and feeding of garbage and with regard to the selection of material for succeeding charges so as to maintain the necessary heat, close attention to all of the dampers for regulating the drafts either when feeding, stoking or cleaning, scrupulous care in seeing that no unburned particles are removed with the ashes, are all simple matters, though when they fail even singly they may give imperfect results, and failing together they may be disastrous.

When the garbage is delivered at the crematory to rapidly, or not in the best order for firing, as already mentioned, it should be stored. The storage may be in the carts themselves, or on the floor near the feeding holes, as done without annoyance in nearly all crematories abroad. When a load of paper, wood and rubbish arrives, it should not, as was observed on one of our visits, be charged on top of a load of fresh garbage, but be dumped to one side and fed at a time when its fuel value for the moist material will be more effective.

This heat value of the dry rubbish is quite appreciable and in one instance was estimated roughly at one-third the value of a ton of coal, without being utilized for the burning of any fresh kitchen garbage.

The temporary storage of the garbage on the floor over the furnace, for a better mixing and drying of the same, requires suitable gutters to be formed on it which will collect the water and carry it to the sewer.

Careful attention must also be given to the auxiliary

Table I.—Percentage Composition of Garbage in Certain Cities in Europe and the United States, Excluding Ashes, Coal and Non-Combustible Rubbish.

Authority.	London. Codrington.	Berlin. Bohm & Grohn.	New York.* Cravens.	Boston. O'Shea.	Trenton, Special Committee on Garbage.
Kitchen garbage, animal and vegetable matter.	77	82	64	84	84
Paper	23	11	28	16	12
Rags, clothing, carpets, etc.		3	8		3
Boxes, barrels and other rubbish.		4			1
	100	100	100	100	100

*Including Brooklyn.

Table II.—Results of Operation of Garbage Crematory at Trenton for Week of Aug. 4-9, Inclusive, 1902.

Total garbage burned	188.0	tons
Garbage burned per day	31.3	"
Coal used on main fires	10.7	"
Coal used on auxiliary fires (estimated)	3.0	"
Total coal used	13.7	"
Coal used per day	2.3	"
Garbage burned per ton of coal	13.8	"
Approximate number of hours burning each day, average	14.0	hrs.
Equivalent No. of days of 24 hrs. for the week.	3.5	days
Equivalent garbage burned per sq. ft. of grate area per day of 24 hours	1,080	lbs.
Equivalent amount of garbage burned per cell of 25 sq. ft., per day of 24 hours	13.5	tons
Estimated total amount of clinkers from garbage and coal grates	14.0	"
Estimated total amount of ashes from below grates	3.0	"
Estimated total amount of ashes and clinkers.	17.0	"
Per cent. ashes and clinkers to garbage burned	9.1%	
Range of temperature of flue gases in stack (estimated)	600°—1,000°	F.
Percentage of moisture in garbage	81.0%	
Corresp'd'g water evaporated daily in furnaces	25.5	tons
Amount of coal required per day to evaporate this water on basis of 10 lbs. water per lb. coal.	2.5	"

fires, so that they burn briskly at times when the conditions for the escape of odorous fumes from the furnace are most favorable.

In short, every attention must be given to the various manipulations so that a complete combustion can be obtained, and this without excessive loss of heat from the burning of any of the combustible material.

All ash pits, flues, dust chambers and other parts of the furnace must be frequently inspected and cleaned, since any deposits may contract the sectional area of the flue and thereby modify the normal draft through them.

RESUME AND RECOMMENDATIONS.

It now remains briefly to summarize the foregoing into a statement of the annoyances you are experiencing, with recommendations of the most efficient practical means of removing them.

Notwithstanding the existing defects and the criticisms which it has been necessary to make, the Trenton furnaces belong to the better class of such plants in our country. The troubles and nuisances with which you are now contending are also more or less common elsewhere.

The chief reason for this fact appears to be the insufficient attention that has been given the subject by those best able to do so. Sufficient inquiries have not been made into all the various causes of the specific troubles so as to correct each and all of them in an intelligent manner. In many quarters there appears to be even a lack of appreciation of the real difficulties involved in the problem, both as regards construction and operation. Especially as to the latter there is a disposition to undervalue the necessity of having operators with a good practical knowledge of firing such a complex material as garbage, so as to obtain complete combustion, of the effects and interaction of drafts in furnaces operated separately but leading into the same main flue, and of the means for settling the dust which rises with the fumes. As soon as these difficulties are more generally appreciated, their proper solutions will no doubt soon follow.

The character of the Trenton garbage collection is at present fairly satisfactory. The best practice in this climate regarding the receptacles at the house suggests galvanized-iron buckets with covers. These become less foul

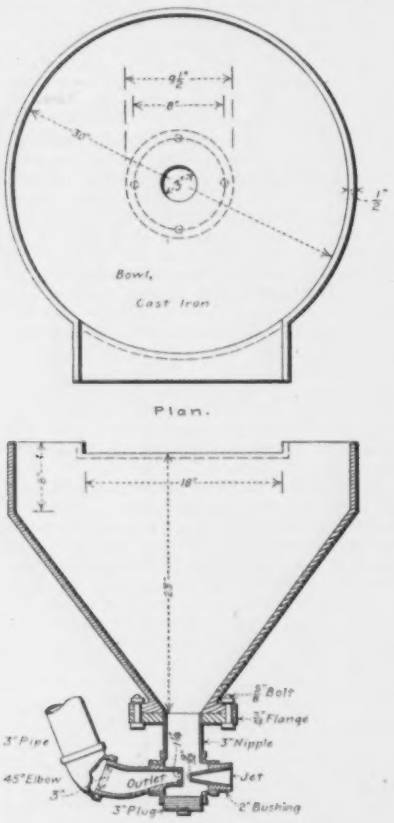


Fig. 2. Details of Sand Washer, Mt. Vernon, N. Y.

than if made of wood, and the covers prevent the scattering of the material by animals or wind and the dissemination of filth by flies.

The collection in well-constructed metal carts such as you have and also the frequency of your collections are quite satisfactory. It may be suggested, however, that provision for thorough cleaning of the carts after dumping would be a still further improvement.

To obviate the escape of odors from ashes that have not been completely burned, it is necessary to have furnaces that will economically burn the garbage, and also very attentive as well as skilful firemen, trained and experienced in this special kind of work.

To obviate the nuisances of dust escaping at the stack, either from well-burned or unburned garbage, it is necessary, after securing perfect combustion, to introduce a dust-settling chamber of proper size between the furnaces and the stack, containing baffles and properly placed inlets and outlets. The screens now in the chimney, although useful as a safeguard against accidental emissions of light but large matter, are insufficient to retain all of the matter now escaping from the furnaces.

To reduce further the possibility of unburned particles escaping through the stack, it is important to place dampers in the flues leading from each furnace, as well as in the chimney, so as to afford control of the drafts at all points where and when it is needed. Skilful observation at every moment of the condition and character of the garbage, and faithful attendance in operating the dampers to maintain an effective velocity of the gases, which at the same time does not carry the dust, are necessary to obtain success.

The prevention of odors due to unburned gases escaping from the stack depends upon the character of the garbage, the sufficient capacity of the furnace, its design, and the operation of the plant.

The garbage now delivered, when properly drained and carefully burned in a well-designed furnace, is readily combustible, and should not require the addition of as much coal as now used, and at some seasons, except to start fires and otherwise on rare occasions, perhaps no coal may be required.

We find that the furnaces are not sufficient in size to effect a complete destruction of the material during the hours of the day when the crematory is operated. Continuous firing for 24 hours can relieve this deficiency. To this end it would be necessary to store the material for a part of the day, and this could not be objectionable in any way.

To secure a complete combustion of the garbage more economically than at present, the design of the furnaces should be somewhat altered. The horizontal grates are not the most suitable for the material, which must first be dried and then with difficulty pulled from one position to another for burning. A sloping grate for burning and a sloping floor for the drying chamber, from which the material can be gradually and almost automatically moved from the feed hole to the hottest fire, permit of a better utilization of the heat and reduce the difficulties of stoking.

The gases should leave the furnace from a point above the hottest fire, and be utilized to heat the walls of the drying chamber so as to assist in the proper preparation of the garbage for burning. Forced draft under the grate will also be of great advantage in aiding combustion.

Auxiliary fires for burning the fumes before they rise into the chimney are a wise addition to your crematory, and should be retained as a safeguard on account of nearness to the inhabited parts of the town.

The recommendations herein made will, I trust, enable you, with the aid of a practical furnace builder, so to alter, increase and supplement certain parts of your present plant as to make it capable of burning the city's garbage. This being done, a systematic attention and skilful practice on the part of the superintendent and his subordinates will enable you to operate the crematory so that nuisances from odors and dust will cease.

SAND WASHERS FOR THE SLOW SAND FILTERS, OF MT. VERNON, N. Y.

The original plan for washing dirty sand at the slow sand filter beds at Mt. Vernon, N. Y.,* was to convey it for some distance by means of a flume of running water. Apparently this plan was never carried out, and no sand seems to have been washed until 1897. In that year a sand washer of the ejector type, shown in detail by Figs. 1 and 2, was installed. Water is supplied from the pumping station through a 2-in. pipe, with 1-in. feed pipes to each ejector. The inlet and outlet of each ejector, and the bottom of each hopper, are connected with a 3 × 3 × 2 × 2-in. cross, the lower end of which is plugged. The dirty sand is thrown onto and falls through a wire screen in the first hopper, and is carried through the four hoppers in succession. From the last hopper the sand falls into a bucket, attached to the boom of a small derrick. When the bucket is full a slide in the trough is closed and another one is opened, so as to fill a second bucket while the first one is being swung away and dumped. In this manner the clean sand is expeditiously removed from the washer.

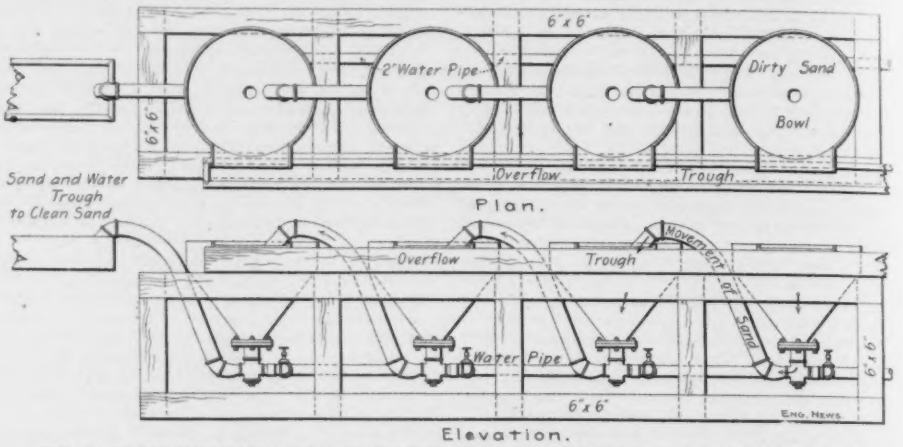


FIG. 1. PLAN AND ELEVATION OF FILTER SAND WASHERS NO. 1, MT. VERNON, N. Y.

A second washer was built in 1900. Except for the fact that it has 10-32-in. jets (see Fig. 3) instead of 9-32-in., and rectangular wooden, instead of circular cast-iron hoppers, it is practically the same as the first washer. The jets used, shown by Fig. 3, are now used in the first washer, also.

Both these sand washers were designed by Mr. A. H. Kneen, Engineer of the New York & Suburban Water Co., to whom we are indebted for the drawings from which our illustrations were prepared. Mr. Kneen states that after some years of experience with the washers, the only changes in design he would suggest are larger overflows and larger bottoms for the iron tanks. The water-works at Mt. Vernon are now controlled by the American Pipe Manufacturing Co., 112 North Broad St., Philadelphia, of which Mr. J. W. Ledoux, M. Am. Soc. C. E., is chief engineer. The water company named above has been reorganized as the New York Inter-Urban Water Co., and supplies Mount Vernon, Mamaroneck, Orienta and Rye Beach. Mr. C. D. Turney is superintendent of the local company.

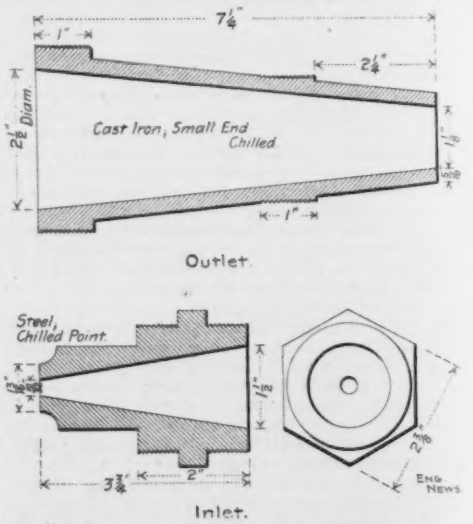


Fig. 3. Sections of Inlet and Outlet Nozzles for Sand Washers No. 2, Mt. Vernon, N. Y.

*See Eng. News, Aug. 23, 1894, for an illustrated description of these filter beds, and for a detailed account of their operation for six years see Eng. News, May 30, 1901.